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Comparing face-to-face and online LSVT®LOUD speech training using LSVT®Coach in patients with Parkinson's disease: a pilot randomised controlled trial

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Abstract

Background LSVT®LOUD is an intensive speech therapy targeting voice amplitude, incorporating proprioceptive feedback and auditory-vocal self-monitoring, delivered through 16 one-hour sessions over a month with a high-effort approach. This study aimed to investigate preliminary effects of LSVT®LOUD teletherapy (LSVT®LOUD-tele) in comparison to traditional face-to-face LSVT®LOUD therapy (LSVT®LOUD-FTF) in people with PD and hypokinetic dysarthria, and to assess the usability of the LSVT®LOUD-tele software and the feasibility of a full-scale randomised controlled trial (RCT).

Methods Using a pilot RCT, 20 people with PD and hypokinetic dysarthria were assigned to either LSVT®LOUD-tele or LSVT®LOUD-FTF, receiving 60-min sessions 4x/week for 4 weeks, along with home-based practice maintaining the same intensity and frequency in both conditions. Primary outcome was voice loudness (sound pressure levels [SPL]). Secondary outcomes included voice handicap, dysarthria-related QoL, HRQoL, and depression, assessed at baseline and post-intervention. The feasibility of conducting a full-scale RCT based on predetermined criteria (33% recruitment rate, 85% retention rate, 75% adherence rate, and high intervention safety) and the usability of the LSVT®LOUD-tele software were assessed post-intervention.

Results Nineteen participants completed the study (10 women). The LSVT®LOUD-FTF group showed improvements in vowel 'Ah' and 'high-pitched A' SPLs (Hedge's g = 1.416 and 0.826), while both groups showed increases in 'low-pitched A' and good quality loud voice SPLs (g = 0.148; g = 0.211). No changes were observed in everyday phrases SPL (g = 0.167) for either intervention, and both groups showed improvements in text reading (g = 0.436) and conversation SPLs (g = 0.345). Subjective voice handicap improved in both groups (eta squared [η^2] = 0.259), while only LSVT®LOUD brought improvement to total dysarthria-related QoL (η^2 = 0.747). HRQoL improvements were noted in activities of daily living, cognition, and bodily discomfort domains after LSVT®LOUD-FTF, and in communication after LSVT®LOUD-tele (η^2 = 0.054–0.386). LSVT®LOUD-FTF led to small improvements in depression, with no significant differences noted between groups. Good-to-excellent usability of LSVT®LOUD-tele was observed, and the feasibility of a full-scale RCT was supported by high overall recruitment, retention, and adherence rates, with no adverse events reported.

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Conclusions Both LSVT®LOUD-tele and LSVT®LOUD-FTF appear effective for people with PD and hypokinetic dysarthria, and the feasibility of a full-scale RCT was confirmed. Larger studies are needed to validate these findings.

Trial registration German Clinical Trials Register, DRKS00027825. Registered on 13.01.2022.

Keywords Parkinson disease, Hypokinetic dysarthria, Speech therapy, Voice training, Voice quality, Rehabilitation, Pilot study

Background

Parkinson's disease (PD) is a neurodegenerative disorder characterised by annual prevalence rates in Europe that vary from 108 to 257 cases per 100,000 individuals [1]. Approximately 90% of people with PD experience various speech impairments throughout the course of their illness, collectively referred to as hypokinetic dysarthria [2]. Noticeable indicators of hypokinetic dysarthria include reduced vocal loudness (hypophonia), pitch and loudness variability, emotive vocalisation, breathy and hoarse vocal quality, festinations, hesitation, and imprecise articulation [3, 4]. Hypokinetic dysarthria significantly contributes to functional communication limitations in people with PD, impacting social interaction and quality of life (QoL), highlighting the pressing need for effective and targeted treatment [5].

The Lee Silverman Voice Treatment (LSVT®LOUD) is one of the most well-researched, efficacious, and widely used interventions for hypokinetic dysarthria in people with PD [6]. LSVT®LOUD focuses on the voice, specifically aiming to increase vocal amplitude by concentrating on attaining, monitoring, and maintaining a loud voice to counteract hypokinetic dysarthria across the speech mechanism, and uses clinician feedback to recalibrate sensory and motor functions related to vocal loudness [6, 7]. The treatment is intensive, consisting of 16 individual 1-h sessions over one month, delivered with a high-effort approach [7, 8]. LSVT®LOUD has shown effectiveness in improving voice loudness in reading and spontaneous speech and functional communication in people with PD [6, 8], with benefits lasting up to two years post-treatment [9].

Despite the evidence supporting the effectiveness of LSVT®LOUD in increasing voice intensity in people with PD, several factors may impede its implementation. Common barriers encompass limitations in mobility and geographic accessibility, shortage of clinicians certified in LSVT®LOUD, and conventional in-person treatment costs [10, 11]. Telerehabilitation, the remote delivery of rehabilitation, offers an alternative and supplementary strategy for addressing communication disorders in people with PD [11]. Several studies using different technologies have shown the effectiveness and non-inferiority of intensive telerehabilitation-delivered LSVT®LOUD [12–14]. These studies used videoconferencing software or an iPad device for LSVT®LOUD delivery [12–14]. The LSVT®Coach software is the platform that online LSVT®LOUD is delivered through a computer, gathering, automating, and recording voice data while providing real-time feedback [10]. Although home-based, independent patient use of a previous version of LSVT®Coach has shown feasibility and efficacy [10], no studies have compared vocal loudness gains between LSVT®LOUD teletherapy using the LSVT®Coach client version (LSVT®LOUD-tele) and face-to-face therapy with the LSVT®Coach professional version (LSVT®LOUD-FTF), nor assessed the usability of LSVT®Coach software. This pilot study aimed to compare changes in voice loudness, voice handicap as perceived by the participants, dysarthria-related QoL, disease-specific health-related QoL (HRQoL), and depression following LSVT®LOUD-tele and LSVT®LOUD-FTF therapy in people with PD with hypokinetic dysarthria. Further aims were to evaluate the usability of the LSVT®Coach software and feasibility of a full-scale randomised controlled trial (RCT).

Methods

Design, setting and timeline

Design and reporting of this non-blinded randomised controlled pilot study are in line with the Consolidated Standards of Reporting Trials (CONSORT) statement [15] (Additional File 1). The study was conducted from 01.02.2022–08.08.2022 at the Centre for Speech and Language Therapy Schellinggasse, Vienna, Austria and in the participants' homes, with all outcome measures performed in the therapy centre.

Participants

The study was advertised on a medical platform (https://www.gtmed.com/en), at neurological outpatient clinics and through patient support groups using information brochures and invitations to participate in the study. A neurologist screened people with PD for eligibility and remained unaware of group allocation, and participants were asked not to disclose their allocated group until study completion. Inclusion criteria involved people with PD diagnosed per the UK Parkinson's Disease Society

Brain Bank criteria [16]; stage I-III on the Hoehn and Yahr scale (H&Y) [17]; aged ≥ 18 years; with adequate cognitive function (German version Mini Mental Status Test [MMST]*[18] score ≥ 24/30); who were clinically stable and on a consistent dose of dopaminergic therapy; had hypokinetic dysarthria affecting their communication abilities; a basic level of computer literacy; and written informed consent. *The MMST was purchased from Hogrefe GmbH, Vienna, Austria. Exclusion criteria were other neurological or psychiatric diseases or a medical condition that could disrupt measurement of the intervention; voice or speech disorder unrelated to PD; and untreated visual/auditory impairment. Prior to intervention, participants had audiometric and videolaryngoscopic assessments by an Ear Nose and Throat specialist to examine vocal fold structure and movement, excluding non-PD-related auditory or laryngeal pathologies.

Due to the exploratory nature of this pilot study, a formal sample size calculation was not conducted. According to Kieser et al. who suggests 10–20 participants per arm [19], the objective was to enrol 30 people with PD within approximately 6 months, necessitated as the study was undertaken in partial fulfilment of the requirements for a Masters degree.

An independent researcher conducted mixed randomisation using both simple and blocked methods with 1:1 allocation to minimise selection bias [20]. Pre-specified block sizes of 4 and 6, generated through an online random number generator (Sealed Envelope, London, UK) were used. After initially using blocked randomisation for 10 people with PD, 3 additional people with PD were allocated using simple randomisation. This was followed by another permuted block of 4 and the random allocation of 3 more participants [20]. The study had to be stopped after the enrolment of a total of 20 participants.

Intervention

Throughout the study, all participants received their usual care, encompassing regular treatments from primary care physicians, neurologists, and various other medical experts, standard administration of medications, nursing support, and access to social services.

- In Group 1, the intervention consisted of 60-min speech teletherapy supervised by an experienced and LSVT®LOUD certified speech and language therapist (SLT; EK), using the client version of LSVT®Coach to deliver patient feedback (LSVT®LOUD-tele), 4x/week, for 4 weeks.
- In Group 2, the intervention involved 60-min face-to-face LSVT®LOUD (LSVT®LOUD-FTF) speech therapy supervised by the same SLT, using the professional version of LSVT®Coach, 4x/week, for 4 weeks.
- For both intervention groups, the SLT utilised the professional version of LSVT®Coach to record data from all patients (Fig. 1).
- Additionally, participants in both groups were instructed to practise at home for 5–10 min on treatment days and up to 30 min on non-treatment days using the client version of LSVT®Coach, adhering to the identical level of intensity and frequency as dur-

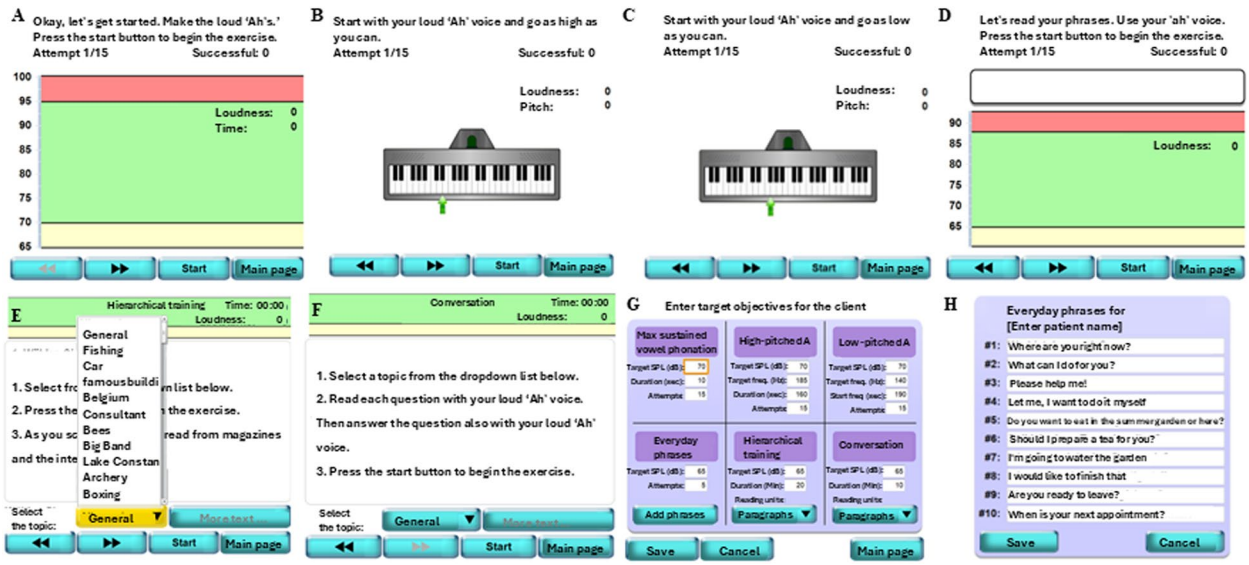

Fig. 1 Professional LSVT®Coach version interface. Maximum sustained 'Ahs' (**A**), 'high-pitched Ahs' (**B**), 'low-pitched Ahs' (**C**), phrases (**D**), hierarchical training (**E**), conversation training instructions (**F**), entering targets for the client (**G**), and selection of daily phrases (**H**)

ing supervised LSVT®LOUD sessions. The data from homework tasks were recorded on the LSVT®Coach client version, exported as an Excel file after each homework session (Additional File 2), and transmitted to the SLT who reviewed the files and recorded patients' adherence to the intervention. Tasks were adjusted as needed at supervised sessions. Participants were encouraged to apply their newly gained voice strength in daily interactions.

The same SLT supervised intervention in both groups in a quiet room (max. 28–33 dB) where participants' vocal loudness (decibel) and quality were monitored during tasks, aiding calibration i.e., enabling self-monitoring and consistent use of a stronger voice. Patient's efforts were monitored using a Visual Analogue Scale (VAS) [21].

Sessions were scheduled based on participants' preferred times of the day and during their ON medication phase, with efforts made to maintain consistency in timing for each participant across the study. The intervention in both groups followed the five LSVT®LOUD principles [22–24] and was individually tailored to the specific communication goals of the participants: focus on voice (boost phonatory output amplitude) (1); enhance perception of effort through 'calibration' (2); employ a high-effort approach during treatment (3); provide intensive treatment (60 min, 4x/week, 16 sessions within 1 month) (4); and measure treatment-related changes (5) [22, 25]. The intervention in both groups was matched on all key variables (intensive dosage, high-effort exercises, amplitude rescaling, and sensory retraining), differing only in the treatment delivery (Table 1).

In both groups, the LSVT® intervention included non-speech and speech exercises that emphasised maximum vocal effort, ensuring healthy voice quality [24]. Initial exercises involved producing a sustained 'ah' sound (maximum sustained vowel phonation, 15x; 12–15 min) at a comfortable pitch but with increased loudness, performed in the first half of the session. These exercises aimed to enhance vocal cord closure / vocal fold adduction, loudness, and phonation duration, while enhancing respiratory drive and training breath-voice coordination [22]. A subsequent pitch modulation exercise targeted recalibration of vocal performance for speaking and to expand the Cricothyroid muscle's range of motion using high and low tones (maximum fundamental frequency range; 15 × from low tone to high tones; 15 × from high tone to low tones; 10–12 min) [4, 7]. To ensure adequate intensity and a foundation for enhancing speaking voice, these foundational exercises were repeated multiple times. (Re-)calibration was facilitated through feedback from the SLT, video and audio recordings, enhancement of self-awareness and acceptability/automation of the louder voice. The strong voice was then directly applied to speech (functional speech loudness drills; 10 individualised daily life phrases; 5–10 min).

During the following speaking exercises in the latter half of the session, participants read progressively longer lists of everyday phrases at a good volume (reading aloud up to 20 + minutes). This exercise aimed to help participants perceive the effort required for optimal speaking volume and enhance self-awareness [26]. Throughout the speaking exercises, a hierarchy of speaking tasks was employed, progressing from single words to sentences to extended language (hierarchical speech loudness tasks performed at high intensity, question–answer, and conversation tasks; 5–10 min). Each step in this hierarchy sought to challenge the patient to maintain maximum speech production, facilitate sensory system retraining for greater loudness, and independently generate the optimum amount of effort using internal cueing/scaling [22, 24]. Specific daily tasks aimed to ensure a smooth carryover of the stronger voice to the patient's daily life functional communication [23].

Teletherapy LSVT®LOUD-tele environment

LSVT®LOUD-tele using the client version of LSVT®Coach software (LSVT® Global Inc., Tucson, AZ, US) for patient feedback was operated via secure videoconferencing software (Jitsi Meet, ©8 × 8, Inc.; https://jitsi.org/) accessed via the server of logopädieaustria, the Professional Association of Austrian Speech Therapists (https://logopaedieaustria.at/). Videoconferencing was established using a 47.0 mbit/s internet connection [27]. Prior to the start of the intervention, the SLT

Table 1 Differences between the LSVT®LOUD-tele and LSVT®LOUD-FTF intervention

Characteristic	LSVT®LOUD-tele	LSVT®LOUD-FTF
Supervised practice environment	Clinician supervising online	Clinician in room
Preparation prior to treatment start	30-min tutorial on utilising the software	None except general introduction
Treatment materials	On screen using LSVT®Coach client version	On screen using LSVT®Coach professional version
Unsupervised home-based practice	LSVT®Coach client version	LSVT®Coach client version

LSVT®LOUD-tele/FTF Lee Silverman Voice Treatment teletherapy/face-to-face therapy

provided participants with a 30-min tutorial on utilising the software. System requirements for delivering the LSVT®LOUD-tele included a Microsoft® compatible 1 GHz Pentium Processor; 512 MB random access memory (RAM); Windows 10; Microsoft® Excel; computer sound card with a loudspeaker or headphone connection and internal/external loudspeakers; and USB connection for external microphone. The LSVT®LOUD-tele followed the same principles as the face-to-face therapy, including sustained 'ah' phonation, high- and low-pitched a, everyday phrases, hierarchical training (words, phrases, sentences, and paragraphs) and conversation tasks; auditive and visual feedback to the patient; the recording, summary, and storage of intervention session data. The LSVT®LOUD-tele tasks were administered remotely 1:1 by the SLT and adjusted to each participant's performance level and needs.

LSVT®LOUD-tele participants assumed a comfortable seated position around 50 cm from the PC monitor and utilised a wearable condenser microphone with selectable omnidirectional and cardioid polar patterns (Samson Technologies, Hauppauge, USA; serial number 01217), positioned on top of the PC. Omnidirectional microphones capture sound equally from all directions while cardioid microphones are most sensitive to sound from the front, effectively isolating sound sources and reducing background noise. SPL values from a minimum of two sustained 'ah' phonations were cross-checked with recorded values to ensure precision.

LSVT®LOUD-FTF environment

Using the professional version of LSVT®Coach software, the LSVT®LOUD-FTF (LSVT® Global Inc., Tucson, AZ, US) intervention was conducted according to standard practice recommendations [22, 24]. In this setting, the participant and clinician sat across from each other at a table, with the PC screen at 50 cm from the patient. To continuously monitor sound levels during the sessions, the microphone (same as for LSVT®LOUD-tele) was placed and constantly maintained at 30 cm from the participant's mouth. Participants received treatment materials in printed format as per standard treatment protocol. The LSVT®LOUD-FTF tasks were individually selected and adjusted to each participant's performance level and needs.

Data collection

Demographic and PD specific information were obtained from participants' medical records at screening. The participants' voice roughness, breathiness, and hoarseness were classified using the roughness, breathiness, and hoarseness scheme [28, 29] on recorded voice samples from participants' reading of the standard text 'North wind and sun' (provided by logopädieaustria; Additional File 3). Roughness referred to irregular vibrations of the vocal fold, breathiness to incomplete closure of the vocal folds, and hoarseness to deviations from the normal vibration pattern of the vocal folds [28, 29].

Study-related objective measurements were taken at baseline and 4-weeks post-intervention by the same SLT that supervised the interventions. The remaining assessments comprised patient-rated outcome measures. Assessments were coordinated to align with the patient's ON medication phase, and care was taken to ensure uniformity in timing for each participant throughout the study.

Primary outcome

The primary outcome was voice loudness, assessed using SPL in decibels dB) across various vocal tasks including 'Ahs', 'high pitched A', 'low pitched A', good quality loud voice, everyday phrases, text reading, and conversation. These measurements were objectively assessed and have established reliability in studies of PD [30]. Data collection took place in a quiet room (max. 28–33 dB) using a fully automated sound level meter (PCE-322A, PCE Deutschland GmbH, Meschede, Germany), positioned near the condenser microphone 30 cm from the patient's mouth [31, 32]. In addition, VidiVoice software (AMD-A6-7400 K-Radion R5.6 Compute, Cores 2C + 4G, 3.5 GHz processor) was utilised for data analysis and visualisation, operating on a 1 GHz Pentium Computer, 512 Mb RAM, Windows 10, 22 Hertz version) [33]. Calibration was performed using sustained 'Ah' vowels over ≥ 4 s following recommended procedures [34] and guidelines [35], with each recording including a reference reading from the sound level meter, recorded on an A-weighted scale [34]. Long-time averaged equivalent sound levels were used. The cleaned and calibrated microphone signals (e.g., edited to remove coughs) were then analysed for SPL, yielding mean and standard deviation values for decibel SPL at a reference distance of 30 cm.

Secondary outcomes

Secondary outcomes comprised the participants' subjective assessment of a voice-related disorder/handicap, dysarthria-related QoL, HRQoL, depression, feasibility of a full-scale RCT, and usability of the client version of LSVT®Coach software. Participants' subjective assessment of a voice-related disorder/handicap was assessed using the Voice Handicap Index (VHI) [36, 37]. The VHI captures three domains of functional, physical, and emotional voice handicap, with scores for each domain ranging from 0 (no perceived handicap) to 40 (most severe handicap) and the total score from 0 to 120. The VHI has demonstrated excellent reliability (Cronbach's α

0.972) and construct validity in people with PD, explaining 71.5% of the total variance through functional, physical, and emotional factors [38]. Significant correlations between the VHI and patient-rated voice impairment and disease characteristics have been found [38].

Dysarthria-related QoL in dysarthria was measured utilising the 40-item German version of the Quality of Life in the Dysarthric Speaker questionnaire (QOL-DyS) [39, 40] capturing four domains: speech characteristics, situational difficulty, compensatory strategies, and perceived reaction of others. Subdomain scores and the total score are rated on a 5-point Likert scale (0–4), with higher values representing more severe dysarthria. In a mixed study population including 6 people with PD, QOL-Dys has demonstrated excellent internal consistency ($\alpha = 0.90$), test–retest reliability (intraclass correlation coefficient, ICC = 0.98, 95% confidence interval, CI = 0.97–0.99), and known-groups validity, significantly differentiating between groups with and without dysarthria ($p < 0.001$) [39]. Significant correlations between QOL-Dys and dysarthria severity were shown ($r = 0.43$) [39].

PD-related HRQoL was assessed using the Parkinson´s Disease Questionnaire-39 (PDQ-39) [41]. The PDQ-39 assesses Parkinson's disease specific HRQoL over the last month and comprises 8 dimensions: mobility, activities of daily living, emotional wellbeing, stigma, social support, cognition, communication, and bodily discomfort. Total scores of each dimension range from 0 (never have difficulty) to 100 (always have difficulty). The PDQ-39 has demonstrated validity, as the eight dimensions identified through principal component analysis, when combined into a higher-order factor, accounted for 56.8% of the total variance in a clinical sample of patients with PD [41]. It showed excellent convergent validity through significant correlations with the Hoehn & Yahr and Columbia rating scales, depending on the construct measured [41]. Additionally, it exhibited excellent internal consistency ($\alpha = 0.84–0.94$) [41].

Depression was recorded using the 21-item revised Beck Depression Inventory (BDI-II) [42], which utilises a 4-point Likert scale from 0 to 3, resulting in a total score between 0 and 63. A score above 10 indicates depression. In people with PD, the BDI-II demonstrated internal consistency ($\alpha = 0.84$) and largely conformed to the bifactorial structure [43]. In terms of construct validity, the BDI-II was significantly related to anxiety measures, but not to apathy [43]. Using the combination of the depression domain of the Neuropsychiatric Inventory and the Parkinson Anxiety Scale as the gold standard, the BDI-II exhibited good accuracy (area under the curve = 0.859), with adequate sensitivity (75%) and specificity (87%) [43].

Feasibility was assessed using predetermined feasibility criteria for conducting a full-scale RCT per study protocol: achieving a recruitment rate target of 33% from an estimated pool of 100 eligible people with PD (equivalent to 5 participants per month) (a); attaining a retention rate target of 85% (b); meeting a minimum adherence rate of 75% for both supervised and home-based interventions (c); a high level of intervention safety, characterised by the absence of severe study-related adverse events, continuously monitored throughout the study (d). We also assessed whether the operation of LSVT®Coach software was technically feasible for the participant.

Usability of the LSVT®Coach client software was evaluated in participants of the teletherapy group using the 21-item Telehealth Usability Questionnaire (TUQ) [44]. TUQ items are assessed using a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree), from which the mean is taken, where higher ratings indicate enhanced system usability [44]. The TUQ offers subscale scores to evaluate usefulness, ease of use, effectiveness, reliability, and satisfaction. The TUG demonstrated good content validity, and all its usability attributes exhibited good to excellent reliability ($\alpha = 0.81–0.93$) [44] and no difference between test and retest ($p = 0.673$) [45]. There was a moderate correlation between the TUQ and the System Usability Scale ($r = 0.52$, $p < 0.0001$ [45].

Statistical analysis

Statistical analysis was performed using IBM SPSS software, version 28.0 (IBM Corporation, Armonk, NY, USA) and GraphPad Prism 8 (GraphPad Software, San Diego, CA, USA). Descriptive statistics were performed as appropriate. The Shapiro–Wilk test was utilised to check for normal data distribution. Hedge's g effect sizes, defined as the corrected standardised mean difference between two groups, calculated based on the pooled and weighted standard deviation, were calculated on the calculated differences between post-intervention and baseline values for parametric tests using the formula [46]:

$$\text{Hedges g} = (\text{M1} - \text{M2}) / \text{SD} * \text{pooled}) \quad (1)$$

where M1 – M2 = difference in means and SD*pooled = pooled and weighted SD.

$$\text{SD} * \text{pooled} = \sqrt{\left((n_1 - 1) * s_1^2 + \left((n_2 - 1) * s_2^2\right)\right)/((n_1 - 1) + (n_2 - 1))} \quad (2)$$

where s_1 and n_1 denotes the SD and number of observations for sample 1, and s_2 and n_2 denote the SD and number of observations for sample 2, respectively [46].

Given the small sample size the following bias correction was performed [47]:

$$((n-3)/(n-2.25))\sqrt{(n-2)/n} \quad (3)$$

where $n = n_1 + n_2$.

A Hedges' g value of 1 signifies that the two groups differ by 1 SD; likewise, a g of 2 indicates a difference of 2 SD, and so forth [46]. For interpretation of Hedges' g values, established criteria were used, with g of 0.2 being considered small, 0.5 medium, and 0.8 large [48].

Non-parametric eta squared (η^2) effect sizes were calculated based on the standardised U values obtained from the Mann Whitney U test conducted on the calculated differences between post-intervention and baseline values [49]:

$$r^2 = \eta^2 = Z^2/\sqrt{n} \quad (4)$$

where Z = the standardised value for the U-value, n = the total number of observations on which Z is based, and $r^2 = \eta^2$ = the index which takes on values ranging from 0 to 1, and when multiplied by 100, it represents the percentage of variance in the dependent variable explained by the independent variable. Established criteria were used for interpreting η^2 values, where 0.01 was considered small, 0.06 medium, and 0.138 large [50].

Feasibility, recruitment and adherence rates were calculated using the Wilson 'score' method propagated by Newcombe (95% confidence interval [CI]); in the case of a proportion close to 0 or 1, a Poisson approximation according to Brown was used [51]. Recruitment, retention and adherence rates (%) were estimated using the following formulae [52]:

$$\text{Recruitment rate} = [(\text{N consenting people with PD})/\text{N eligible people with PD}]*100 \quad (5)$$

$$\text{Retention rate} = [(\text{N study completers})/\text{N total sample}]*100 \quad (6)$$

$$\text{Adherence rate} = [(\text{N performed LSVT sessions})/\text{N scheduled LSVT sessions}]*100 \quad (7)$$

Results

Of 51 screened people with PD, 20 were randomised and 19 completed the study, corresponding with a 5% attrition rate. One participant in the LSVT®LOUD-FTF group withdrew from the study due to a loss of interest in continued participation. Time constraints related to the first author's Master's study forced recruitment to cease prior to reaching the target sample size. A CONSORT flow diagram for pilot and feasibility studies [15] is shown in Fig. 2.

Baseline characteristics

Ten women and 9 men, median age of 70.3 years (minimum–maximum 51.2–77.3) completed the study (Table 2). Median disease duration was 6.3 years (2.3–20.4) and median H&Y score 2 (1–3). Aside from gender, which varied by chance, the groups were similar in terms of demographic characteristics and baseline primary and secondary outcomes.

Primary outcome

Improvements in the vowel 'Ah' and 'high pitched A' SPLs were observed in the LSVT®LOUD-FTF group but not the LSVT®LOUD-tele group. Improvements in 'low pitched A' and good quality loud voice SPLs were found in both groups. There were no changes in everyday phrases SPL after either intervention while improvements in text reading and conversation SPLs were seen in both groups. Overall effect sizes ranged from negligible to large (Table 3).

Secondary outcomes

At baseline, participants' voice handicap was classified as moderate. From baseline to post-intervention, some improvements in participants' subjective assessment of their voice handicap were seen after LSVT®LOUD-tele and LSVT®LOUD-FTF, and total VHI effect sizes were small (Fig. 3 and Additional Table 1). For total dysarthria-related QoL, there were improvements in the LSVT®LOUD-FTF group, with large overall effects. With respect to PD-related HRQoL, improvements were seen in the activities of daily living, cognition, and bodily discomfort PDQ-39 domains after LSVT®LOUD-FTF, and in the communication domain after LSVT®LOUD-tele. Effect sizes were negligible to small. No changes in BDI-II depression scores were observed in either group (Additional Table 1).

The predetermined feasibility criteria for conducting a full-scale RCT were met, as shown by a recruitment rate of 39.2% (95% CI 25.8–53.9) [target: 33%], retention rate of 95% (95% CI 75.1–99.9) [target: 85%], adherence rates for the supervised and home-based intervention of 99.1% (95% CI 68.7–99.6) and 100% (95% CI 75.9–100) respectively [target for each: 75%], with no adverse events reported during the study [target: no severe study-related adverse events].

All teletherapy sessions proceeded without technical complications and with adequate audio quality for

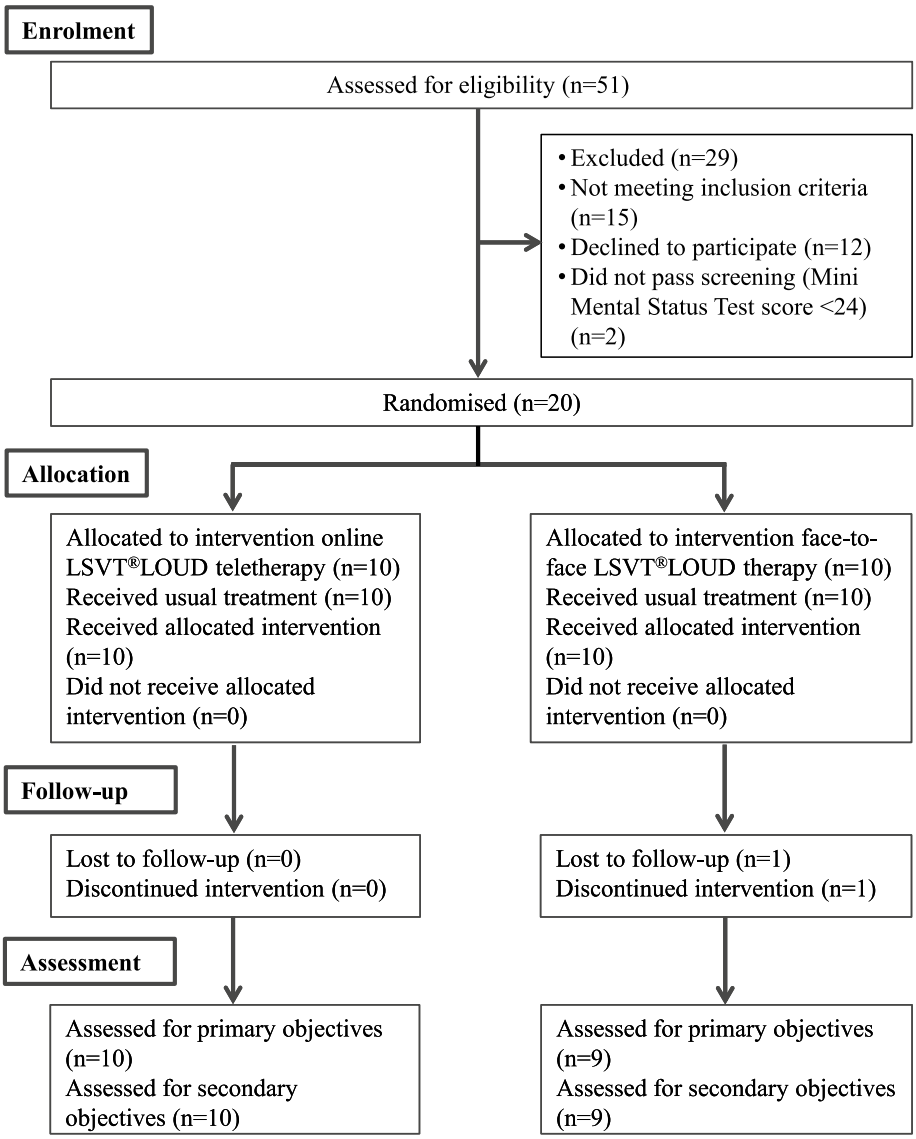

Fig. 2 CONSORT flow diagram, LSVT: Lee Silverman Voice Treatment

intervention delivery. Participants' ratings of the usability of the LSVT®LOUD-tele software utilising the TUQ indicated good to excellent system usability (Table 4).

Discussion

Aims of the present pilot study were to compare LSVT®LOUD-tele and LSVT®LOUD-FTF therapy, with respect to changes in the voice loudness (SPL), voice handicap as perceived by the participants, dysarthria-related QoL, disease-specific HRQoL and depression in people with PD and hypokinetic dysarthria. Further aims were to evaluate the usability of the LSVT®LOUD-tele software and feasibility of a full-scale RCT.

Improvements in the vowel 'Ah' and 'high pitched A' SPLs were observed in the LSVT®LOUD-FTF group but not the LSVT®LOUD-tele group. Improvements in 'low pitched A' and good quality loud voice SPLs were found in both groups. These results are consistent with other studies that found telerehabilitation with LSVT®LOUD to be noninferior on sustained vowel phonation [12]. In contrast to our findings, other research reported significant improvements in SPL across all vocal tasks when combining LSVT®LOUD-FTF with unsupervised home LSVT®Coach sessions [10]. There were no changes in everyday phrases SPL after either intervention, while improvements in text reading SPL and conversation SPL were seen in both

Table 2 Participants' baseline characteristics

Parameter	LSVT®LOUD-tele group; *N* = 10	LSVT®LOUD-FTF group; *N* = 9	*p*-value
Age (years)[a]	71.0 (51.2—77.3)	70.0 (51.2—73.1)	0.842
Sex (males / females)[b]	7 (36.8) / 3 (15.8)	2 (10.5) / 7 (36.8)	0.070
Disease duration (years)[a]	6.8 (4.5—17.3)	6.3 (2.3—20.4)	0.278
Hoehn & Yahr scale[a]	2 (1—3)	2 (1—3)	1.000
L-dopa equivalent dose[a]	451 (0—1124)	402 (0—948)	0.447
MMST[a]	30 (27—30)	30 (27—30)	1.000
RBH	R1 B0 H1	R1 B0 H1	0.661

LSVT®LOUD-tele/FTF Lee Silverman Voice Treatment teletherapy/face-to-face therapy, *MMST* Mini Mental Status Test, *N* number of participants, *RBH* voice roughness, breathiness, and hoarseness, classified according to the RBH scheme (median values)

[a] Values represent median (minimum–maximum)

[b] Values represent frequency (percentage)

groups. The changes in conversation are especially relevant to the daily lives of people with PD and align with the data reported by Ramig et al. for LSVT®LOUD-FTF [7]. However, only three participants in the LSVT®LOUD-tele group and two participants in the LSVT®LOUD-FTF group achieved a clinically significant improvement of ≥ 4.5 dB in conversation SPL [13]. With the good quality loud voice and values around 72–76 dB, participants in both groups did not reach target maximum SPL of > 90 dB [32, 53]. Insufficient laryngeal function and abnormal laryngeal somatosensory function could have contributed to the lower vocal loudness in our participants [54, 55].

The second central question of this study was to determine if there are disparities in the preliminary efficacy of LSVT®LOUD-tele and LSVT®LOUD-FTF speech training concerning participants' subjective assessments of a voice disorder, dysarthria-related QoL, disease-specific HRQoL, and depression. We used questionnaires to collect subjective feedback from participants about their voice disorder. At baseline, participants' voice handicap was classified as moderate. Based on the Voice Handicap Index (VHI), participants in both groups reported some improvements from baseline to post-intervention, although these effects were of small magnitude. This could be due to participants' initial perceptual deficits regarding their speech disorder and increased awareness over the course of the study. The use of the LSVT®Coach software, which offers real-time feedback, appears to

Table 3 Changes in SPL in the two intervention groups

Parameter	LSVT®LOUD-tele group; *N* = 10	LSVT®LOUD-FTF group; *N* = 9	Hedge's g effect size
Vowel Ah SPL BL	80.26 (5.33)	76.47 (3.96)	
Vowel Ah SPL PI	79.48 (5.69)	81.44 (2.78)	
Vowel Ah SPL Diff. PI-BL	−0.78 (3.48)	4.98 (4.64)	1.416
High pitched A SPL BL	82.30 (5.37)	77.12 (4.31)	
High pitched A SPL PI	81.19 (4.74)	79.28 (2.71)	
High pitched A SPL Diff. PI-BL	−1.11 (3.87)	2.16 (4.06)	0.826
Low pitched A SPL BL	70.49 (22.88)	73.86 (3.42)	
Low pitched A SPL PI	75.72 (4.56)	76.73 (3.12)	
Low pitched A SPL Diff. PI-BL	5.23 (21.43)	2.88 (4.30)	0.148
Good quality loud voice SPL BL	75.11 (4.61)	72.63 (4.81)	
Good quality loud voice SPL PI	76.70 (5.70)	75.67 (5.62)	
Good qu loud voice SPL Diff. PI-BL	1.59 (6.86)	3.03 (6.77)	0.211
Everyday phrases SPL BL	73.45 (4.80)	72.74 (3.35)	
Everyday phrases SPL PI	73.93 (4.18)	72.73 (1.98)	
Everyday phrases SPL Diff. PI-BL	0.48 (2.64)	−0.01 (3.22)	0.167
Text reading SPL BL	63.52 (1.57)	62.97 (3.58)	
Text reading SPL PI	65.32 (2.92)	65.89 (3.61)	
Text reading SPL Diff. PI-BL	1.80 (2.42)	2.92 (2.72)	0.436
Conversation SPL BL	63.07 (3.34)	61.16 (3.52)	
Conversation SPL PI	63.86 (3.91)	63.44 (3.77)	
Conversation SPL Diff. PI-BL	0.79 (5.38)	2.29 (2.74)	0.345

Values represent mean (standard deviation)

BL Baseline, *Diff.* difference, *LSVT®LOUD-tele/FTF* Lee Silverman Voice Treatment teletherapy/face-to-face therapy, *N* number of participants, *PI* post-intervention, *SPL* sound pressure level (decibel)

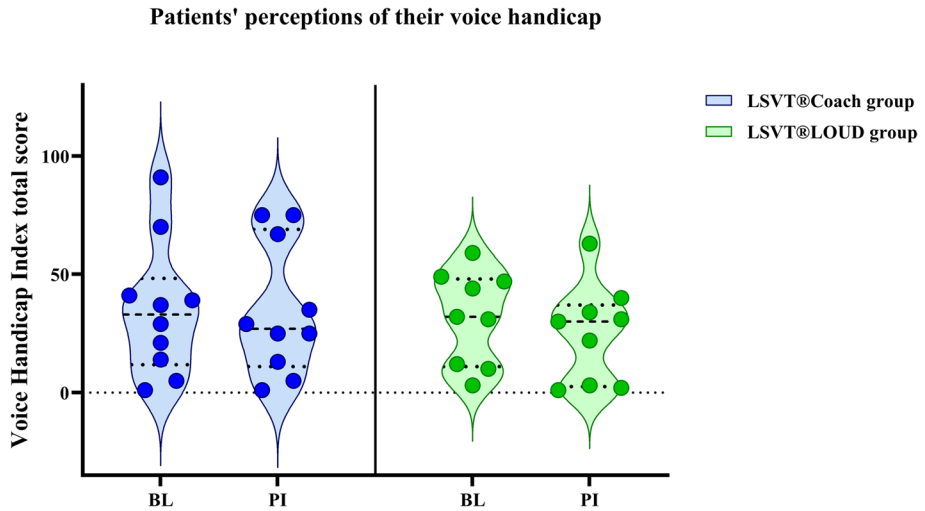

Fig. 3 Changes in the patients' perceptions of their voice handicap. Violins show ranges, dotted lines represent 25th and 75th percentiles and dashed lines medians in LSVT®LOUD-tele and LSVT®LOUD groups respectively, for patients' perceptions of their voice handicap. BL: baseline; LSVT: Lee Silverman Voice Treatment; PI: post-intervention

have contributed to changes in participants' self-monitoring and their ability to regulate vocal motor behaviours. Other studies have reached similar conclusions based on the apparent discrepancy between objective improvements in SPL and only modest enhancements in participants' subjective assessments of their voice disorder [10]. In contrast, other research found that people with PD reported improvements in their ratings of communicative effectiveness across various situations after undergoing LSVT®LOUD and LSVT®articulation treatment [7]. Our findings align with a growing body of literature indicating that abnormalities in auditory-vocal integration, characterised by difficulties in perceiving errors in voice auditory feedback and regulating vocal motor behaviours, significantly contribute to hypokinetic dysarthria in people with PD [56, 57]. For instance, people with PD have been found to overestimate their speech loudness during both reading and conversation [31, 58]. Additionally, sensory deficits in people with PD have been associated with various factors such as the timing of phonatory onset, voice intensity, respiratory driving pressure, laryngeal resistance, lung volume per syllable, disease severity, and speech-related impairment [54]. Studies have also identified abnormal voice auditory feedback in people with PD, suggesting that abnormal voice control in these people may be related to dysfunctional mechanisms of error detection or correction in sensory feedback processing [59]. Our observations could be explained by both the perceptual deficits in participants regarding Parkinsonian speech deficits and the relatively small magnitude of some observed changes. This hypothesis is consistent with the results showing overall dysarthria-related QoL improvements in the LSVT®LOUD-FTF group, with large overall effects.

Regarding HRQoL, there were improvements in the activities of daily living, cognition, and bodily discomfort PDQ-39 domains after LSVT®LOUD-FTF, and of communication in the LSVT®LOUD-tele group. Surprisingly, effect sizes were negligible to small. No changes in depression were found in any group. This suggests that both interventions may have some positive effects on different aspects of dysarthria-related QoL and HRQoL. Our results align with previous research that examined the impact on QoL of LSVT®LOUD-FTF therapy and online therapy utilising alternative technologies [14]. We found that all teletherapy sessions delivered by LSVT®LOUD-tele proceeded seamlessly without any

Table 4 Usability rating of the LSVT®LOUD teletherapy software in the respective treatment group

Parameter	LSVT®LOUD-tele group; *N* = 10
TUQ Usefulness Subscale	6.0 (4.3–7.0)
TUQ Ease of Use Subscale	6.1 (4.3–7.0)
TUQ Effectiveness Subscale	6.0 (5.4–7.0)
TUQ Reliability Subscale	5.8 (4.3–7.0)
TUQ Satisfaction Subscale	6.5 (5.7–7.0)
TUQ total	6.2 (5.0–7.0)

Values represent median (minimum–maximum)

LSVT®LOUD-tele Lee Silverman Voice Treatment teletherapy, *N* number of participants, *TUQ* Telehealth Usability Questionnaire, where higher values indicate better usability

technical complications. Adequate audio quality was maintained for intervention delivery. This suggests that LSVT®LOUD-tele is technically feasible, confirming findings from previous research using earlier versions thereof [10]. Consequently, our study has contributed to the literature on the usability of the LSVT®Coach client version. Additionally, participants rated the usability of the LSVT®LOUD-tele software as good to excellent using the TUQ, indicating that the system was well-received by the participants. Good usability of the LSVT®LOUD-tele software appears relevant in ensuring its accessibility, efficiency, usefulness, and effectiveness [60]. Finally, the study met the predetermined feasibility criteria for conducting a full-scale RCT. We observed improvements after both LSVT®LOUD-tele and LSVT®LOUD-FTF, with respect to the primary outcome of voice loudness. These results were used to inform the sample size calculation of a full-scale RCT. Utilising G*Power version 3.1.9.7 [61], with an assumed power of 80%, a type I error probability of 0.05, a two-tailed test, and effect size of $r = 0.5$ (SPL effect sizes mean), a total sample size of 128 participants is needed to detect a true between-group difference. Including a 20% attrition rate, a total sample size of 160 participants is required.

Study limitations

The primary limitation of this study is the small sample size, exacerbated by the challenge of not achieving the intended enrolment of 30 people with PD within the allotted timeframe. Nonetheless, feasibility criteria were met. Second, the same therapist delivered the intervention and assessed the participants, which prevented the implementation of blinding in the study. However, the primary outcome was objectively measured using a calibrated sound-level meter and all other outcomes were assessed using patient-reported outcome measures. Third, the limitations of the MMST were not considered during the study conceptualisation. Relevant evidence [62] suggests that this oversight may have limited our ability to detect the cognitive changes typically associated with PD, which relate to cognitive support needs and engagement with the intervention, particularly in home-based practice. This may have in turn affected participant engagement and therapeutic outcomes. Fourth, the QOL-Dys validation study included only 6 people with PD, potentially limiting its applicability to this population. Fifth, this study focused on people with PD with hypokinetic dysarthria, excluding those with cognitive impairment, relevant comorbidities and severe PD, and non-PD-related auditory or laryngeal pathologies. Therefore, results cannot be applied to people with more severe PD or mild cognitive impairment, so further research is needed.

Conclusions

In conclusion, results from this pilot study suggest that both LSVT®LOUD-tele and LSVT®LOUD-FTF therapy leads to improvements in voice loudness and various aspects of (HR)QoL for people with PD with hypokinetic dysarthria. Participants found the LSVT®LOUD-tele software to be user-friendly, and feasibility of a full-scale RCT was shown. Further research is warranted to validate these findings and provide more definitive insights into the effectiveness of these interventions.

Abbreviations

BDI-II	Revised Beck Depression Inventory
CA	California
CI	Confidence interval
CONSORT	Consolidated Standards of Reporting Trials
HRQoL	Health-related quality of life
H&Y	Hoehn and Yahr scale
LSVT	Lee Silverman Voice Treatment
M1	Mean 1
M2	Mean 2
MMST	Mini Mental Status Test
NY	New York
η^2	Eta squared
PD	Parkinson's disease
QoL	Quality of life
QOL-Dys	Quality of Life in the Dysarthric Speaker
PC	Personal computer
PDQ-39	Parkinson´s Disease Questionnaire-39
RAM	Random access memory
RBH	Roughness, breathiness, and hoarseness
RCT	Randomised controlled trial
SD	Standard deviation
SLT	Speech and language therapist
SPL	Sound pressure level
TUQ	Telehealth Usability Questionnaire
UK	United Kingdom
USA	United States of America
VAS	Visual Analogue Scale
VHI	Voice Handicap Index

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12883-025-04161-0.

Additional file 1. CONSORT 2010 checklist of information to include when reporting a pilot or feasibility trial.

Additional file 2. Recording examples of home-based practice (German).

Additional file 3. LSVT® intervention: text north wind and sun.

Additional file 4: Table 1. Changes in voice handicap, dysarthria- and health-related quality of life, and depression in the two intervention groups.

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Authors' contributions

E.K. and B.S. conceptualised the study and oversaw overall direction and planning. E.K., D.V., and B.S. contributed to the design and implementation of the research. J.S. and B.S. were involved in analysing the results and drafting the manuscript, with input from all authors. All authors read and approved the final manuscript.

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Data availability
All data generated or analysed during this study are included in this published article and its' supplementary information files.

Declarations

Ethics approval and consent to participate
This study adhered to the Declaration of Helsinki (2013). Ethics approval was obtained from the Danube Private University research ethics committee (10.01.2022; reference: EK/012). Written informed consent was obtained from all participants prior to enrolment.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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