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Effectiveness Of Speech Therapy Interventions In Parkinsonism: Mechanisms And Rehabilitation: A Systematic Review

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ABSTRACT

Background: *Speech impairments, especially hypokinetic dysarthria, affect up to 89% of Parkinson's disease patients, impairing communication, and general lifestyle. Speech-language therapy (SLT) is a key non-drug approach, offering greater benefit than medications for speech issues.*

Objective: *This systematic review evaluates the efficiency of speech and language therapy in Parkinsonism, investigates underlying therapeutic mechanisms, and examines the impact of delivery modes and personalized intervention strategies.*

Methods: *A complete literature search was conducted following the PRISMA 2020 guidelines. Studies included adults with Parkinson's disease receiving speech and language therapy (SLT) interventions, such as Lee Silverman Voice Treatment (LSVT) LOUD, LSVT ARTICulation, clear speech strategies, music therapy, and telehealth-based programs. 13 studies met inclusion criteria: randomized controlled trials, experimental, and quasi-experimental designs.*

Results: *LSVT LOUD significantly improved vocal loudness, speech intelligibility, and quality of life. Telehealth-based SLT showed comparable efficacy to in-person delivery, improving accessibility. Multi-modal and customized approaches yielded positive outcomes in communication and functional independence. However, heterogeneity in protocols and outcome measures limited cross-study comparability.*

Conclusion: *SLT interventions, particularly LSVT LOUD, are effective in improving speech outcomes in PD. Emerging modalities such as telehealth and individualized, multi-disciplinary rehabilitation enhance therapy accessibility and impact. Future research should prioritize long-term, patient-centered studies and standardized outcome metrics to strengthen evidence-based clinical practice.*

Keywords: *Parkinson's Disease, Speech Therapy, Hypokinetic Dysarthria, Telehealth, Systematic Review, Communication Disorders*

INTRODUCTION

Parkinsonism, including Parkinson's disease (PD) and related disorders, notably affects quality of life through motor symptoms like bradykinesia, tremor, rigidity, and speech difficulties [5]. Hypokinetic dysarthria, affecting up to 89% of PD patients, manifests as altered speech rhythm, monotonous pitch, decreased vocal volume, and impaired articulation [3,4]. These communication challenges contribute to social withdrawal and psychological distress, emphasizing the need for effective therapeutic strategies [1].

Dopamine depletion is the primary cause of speech impairment in PD, and while pharmacological treatments like Levodopa may alleviate some motor symptoms, their effectiveness on speech-related issues is inconsistent [4,6]. This has heightened the emphasis on speech and language therapy (SLT) as a crucial non-pharmacological treatment. SLT has shown significant improvements in speech parameters, though outcomes depend on dysarthria severity,

therapy duration, and adherence [1,3]. Intensive techniques like Lee Silverman Voice Treatment (LSVT LOUD) focus on vocal loudness and show promising outcomes [8,9].
Emerging modalities, including telehealth-based SLT, offer improved accessibility and hold potential for enhancing treatment engagement [2]. Research continues on how tailored SLT programs can optimize speech outcomes by addressing individual patient needs, while multidisciplinary approaches combining speech therapy with physical and occupational therapies have shown effectiveness in improving overall functional independence. Despite advances, there remains a need for standardized protocols, clearer outcome measures, and exploration of alternative interventions.
This systematic review aims to evaluate the efficiency of various SLT interventions in improving speech function in individuals with PD, explore their underlying mechanisms, and assess their role in fostering long-term communication abilities. By synthesizing recent clinical trials and meta-analyses, it provides evidence-based insights to guide clinicians and policymakers, improving patient care and quality of life (QoL).

METHODOLOGY

The review is guided by specific research questions and structured using the PICOS framework to ensure a comprehensive and focused analysis.

Research Questions:

- **RQ.1 How effective are different speech therapy interventions in enhancing speech function in individuals with Parkinson's disease**?
- **RQ.2 Can customized treatment programs maximize outcomes?**
- **RQ.3 Evaluate the differences in intervention protocols, therapy durations, and outcome assessments?**

PICOS Framework:

- **Population**: adults diagnosed with PD presenting with dysarthria or communication impairments;
- **Intervention**: speech therapy interventions, including LSVT LOUD, LSVT ARTIC, clear speech strategies, multidisciplinary rehabilitation, music therapy, and tele-rehabilitation approaches;
- **Comparator**: standard care, no treatment, sham therapy, or alternative speech therapy interventions;
- **Outcomes**: primary outcomes such as voice intensity (SPL), intelligibility, articulation, phonation measures, and secondary outcomes including QoL indices, VHI, and caregiver burden;
- **Study design**: randomized controlled trials (RCTs), parallel-group, and experimental studies. Eligible studies were screened and selected according to predefined inclusion criteria.

Search Strategy: A systematic literature search was conducted in accordance with PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The databases searched included PubMed, Embase, Scopus, Cochrane Library, Web of Science, and CINAHL. The search strategy utilized a combination of Medical Subject Headings (MeSH) terms and free-text keywords, with Boolean operators (AND, OR) to refine results. Key terms included "Parkinson's disease," "parkinsonism," "speech therapy," "speech and language therapy," "hypokinetic dysarthria," "LSVT LOUD," "telerehabilitation," "multi-modal therapy," "communication disorders," and "voice treatment." Manual searches of reference lists were also conducted to ensure comprehensive coverage.
Selection Criteria: Among 638 articles screened, 13 were included in the review (Figure 1). These studies involved individuals diagnosed with Parkinson's disease or parkinsonism, focusing on RCTs, cohort studies, and systematic reviews/meta-analyses. Only studies evaluating SLT interventions and reporting quantitative speech-related outcomes, such as vocal intensity, articulation, and intelligibility, were included. Peer-reviewed full-text articles published in English were considered. Exclusion criteria included case reports, conference abstracts, editorials, and studies without measurable speech-related outcomes. Non-English publications without available translations were also excluded. This approach ensured the inclusion of high-quality evidence while minimizing bias.

Data Extraction and Synthesis: This was independently conducted by two reviewers (Dr. Arthi and Dr. Lavanya) using a standardized form. Extracted data included various parameters, as shown in Tables 1 and 2. Discrepancies were resolved through discussion and consensus. A qualitative synthesis of study characteristics and outcomes was performed, with quantitative comparisons made, considering variability in interventions, delivery modes, and outcome measures.

Risk of Bias Assessment: The methodological quality of RCTs was assessed using the Cochrane Risk of Bias 2.0 (RoB 2.0) [19] tool and the Newcastle-Ottawa Scale (NOS) [20]. RoB 2.0 evaluated 5 domains, with judgments

classified as low risk or some concerns. NOS assessed Selection, Comparability, and Exposure, assigning stars for quality.

Figure 1: PRISMA 2020 Flowchart for the review

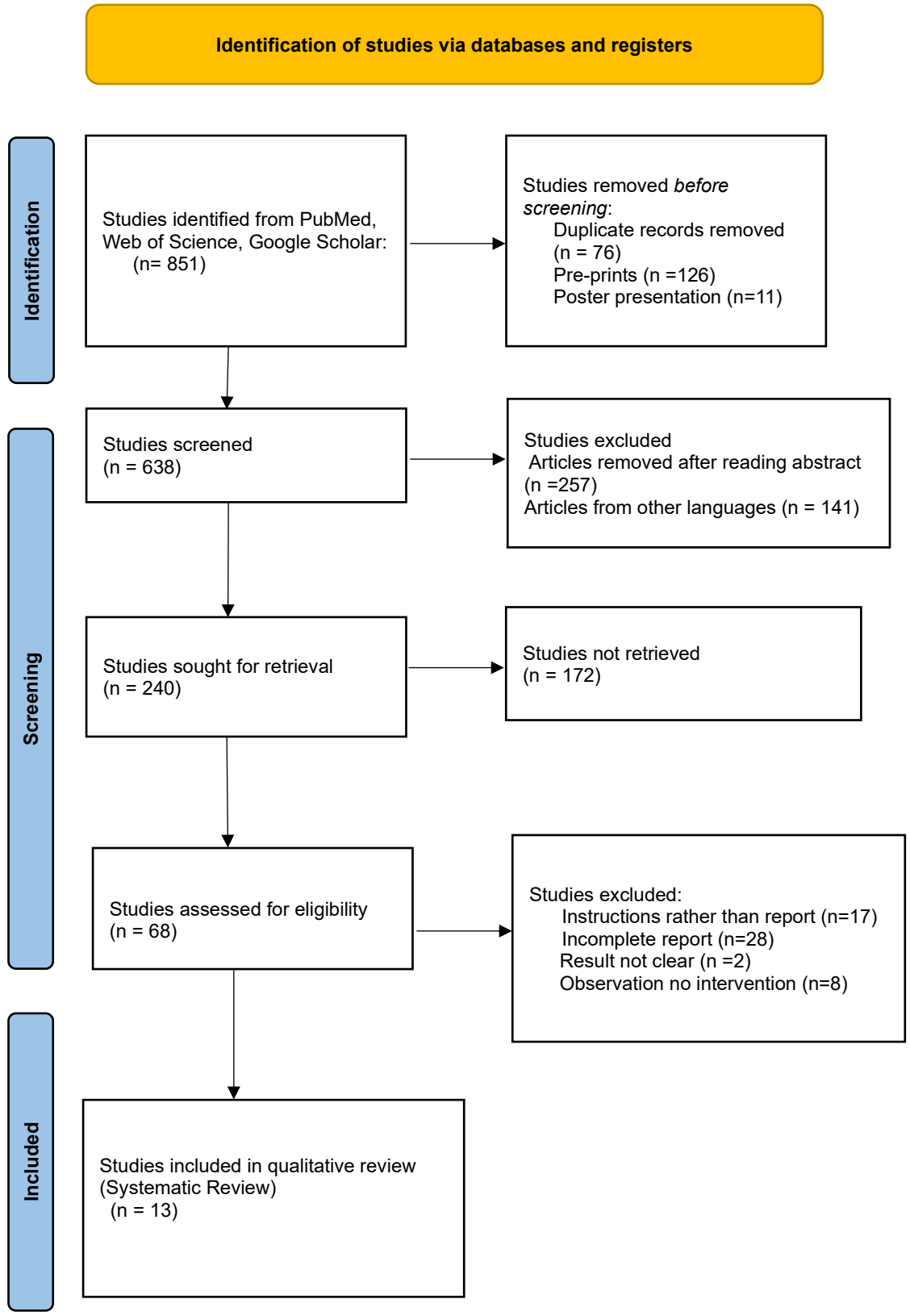

Table 1: Summary of Key Studies on Speech Therapy Interventions in PD

Author (Year)	Design	n	Population (Age/Gender)	PD Details	Comparison	Setting	Outcomes & Conclusion
Theodoros et al. (2016) [9]	Single-blind RCT	52	71.0 ± 8.8; 36M/16F	H&Y 1–5; mild-mod dysarthria	F2F (16), Online (15), Non-metro Online (21)	In-person/Telehealth	Online = F2F; ↑ SPL, intelligibility, QoL
Lam et al. (2016) [17]	Acoustic study	28	PD: 68.3 ± 6.7; C: 67.8 ± 6.5; 9M/5F PD	Idiopathic PD; mild dysarthria; some LSVT	Healthy controls	In-person	Overenunciation ↑ articulation; hearing-impaired ↑ prosody
Ramig et al. (2018) [6]	Unblinded RCT	64 PD; 20 HC	PD ~67 yrs, 68.8% M; HC ~64 yrs	H&Y I-IV; 5 yrs disease	LSVT LOUD, ARTIC, untreated	In-person	LSVT LOUD ↑ SPL, CETI-M at 1 & 7 mo
Ferrazzoli et al. (2018) [10]	Single-blind RCT	234	66.5 (exp), 66.9 (ctrl); 57% M	H&Y 2–4; stable meds	No rehab	In-person	MIRT ↑ QoL, motor & functional outcomes
Sackley et al. (2020) [21]	Multicentre RCT	546	Not reported	Idiopathic PD	No Rx, NHS SLT, LSVT	In-person	SLT ↑ speech vs. no Rx
Levy et al. (2020) [7]	RCT	57	66.5 ± 8.5; 72% M	H&Y I-IV; ~4.9 yrs dx	LSVT LOUD, ARTIC, no Rx	In-person	LSVT LOUD ↑ intelligibility
Brabenec et al. (2021) [22]	Sham-controlled RCT	33	71.7 (real), 71.5 (sham); 14M/6F	Mild-mod dysarthria	Sham rTMS	In-person	rTMS ↑ phonetics, brain activation (8 wk effect)
Maas et al. (2022) [12]	RCT (Protocol)	215	<46 to >66; stratified genders	All PD stages; ↓ intelligibility	Waitlist (8 wk)	Telehealth	Home voice app; evaluating QoL, speech
Mohseni et al. (2023) [23]	RCT	33 (25M/8F)	Mean 58.9 yrs	H&Y 1–2; dysphagia	ST, Music Tx	Telehealth (WhatsApp)	Combo ↑ swallowing; telerehab feasible

Maas et al. (2024) [11]	RCT	214	68.1 yrs; 27% F	All stages; dysarthria; mean dx 7.8 yrs	Waitlist (105)	Telehealth	↑ communication QoL; no QoL change
Sackley et al. (2024) [8]	Unblinded RCT	388	~70 yrs; 74% M	H&Y ≤3; dysarthria	LSVT, NHS SLT, no SLT	In-person/home; LSVT remote	LSVT ↓ dysarthria impact; no AE
Sackley et al. (2024) [18]	Phase III RCT	388	~70 yrs; 74% M	H&Y ≤2 in 61%; 5–6 yrs PD	LSVT, NHS SLT, no SLT	In-person/home	LSVT ↑ speech; NHS SLT = control
Steurer et al. (2024) [24]	RCT (EXPAND)	95	≥60 yrs; MoCA ≥21	H&Y 2–3; mild-mod PD	HiComm vs. HiBalance	In-person/home	HiComm ↑ post-voice; effect not retained

Footnote: F2F: Face-to-Face; SPL: Sound Pressure Level; QoL: Quality of Life; H&Y: Hoehn and Yahr; LSVT: Lee Silverman Voice Treatment; SLT: Speech-Language Therapy; PD: Parkinson's Disease; VHI: Voice Handicap Index.

Table 2: Summary of Key Findings, Outcome Measures, and Efficacy of Speech Therapy Interventions in Parkinsonism

Author / Year	**Intervention Type**	**Primary Outcomes**	**Secondary Outcomes**	**Main Findings**	**Statistical Significance (p-value)**	**Effect Size**	**Mean Outcome Scores (Pre/Post/Follow-up)**	**Duration of Intervention / Follow-up**
Theodoros DG et al. (2016) [9]	LSVT LOUD (face-to-face & telerehabilitation)	SPL in monologue (dB)	SPL in sustained phonation /reading; Max F0; intelligibility, loudness, pitch variability; Dysarthria Impact Profile; PDQ-39	Telerehab noninferior to face-to-face. Significant improvements in loudness, intelligibility; no difference between delivery modes.	$p < .001$ (time effect); no group × time interaction ($p > .05$)	Not reported	SPL (Mono): 69.6/77.1 (FTF), 70.2/76.4 (Online); Intelligibility: 107.3/127.1 (FTF), 120.5/125.9 (Online)	16 sessions (4 weeks); post-treatment follow-up

Lam J et al. (2016) [17]	Clear Speech Variants (Habitual, Clear, Overenunciate, Hearing Impaired)	Vowel Space Area (VSA), vowel duration, fricative duration	F0, SPL, articulation rate	Overenunciate improved VSA, vowel duration, articulation rate. Hearing impaired increased SPL and F0. Feasible interventions for PD.	$p < 0.05$ for multiple measures	$\eta p^2 = 0.02–0.70$	Pre: 69.7–71.5; Post: 70.3–72.5; Follow-up: 73.2–76.6	Single-session tasks; no follow-up reported
Ramig L et al. (2018) [6]	LSVT LOUD vs. LSVT ARTIC (both intensive, PD-specific)	SPL in reading & spontaneous speech	CETI-M	LSVT LOUD improved SPL significantly at 1 & 7 months. CETI-M improved at 1 month for both groups but maintained at 7 months only in LOUD group.	SPL $p < 0.05$; CETI-M $p = 0.02$ (1 mo), $p = 0.08$ (7 mo)	SPL: ES = 1.53 (LOUD vs ARTIC), 2.19 (LOUD vs UNTXPD)	LSVT LOUD: Pre 70.5 / Post 76.8 / Follow-up 75.2; LSVT ARTIC: Pre 71.9 / Post 73.2 / Follow-up 72.5	1 month (16 sessions); 7-month follow-up
Ferrazzoli D et al. (2018) [10]	Multidisciplinary Intensive Rehabilitation Treatment (MIRT) incl. speech therapy	PDQ-39 Global Index	UPDRS, PDDS, TUG, BBS, Levodopa dosage, neuropsychological tests	Significant QoL improvement (PDQ-39 ↓ by 8.3 at 10 wks, maintained at 18 wks);	PDQ-39, UPDRS, PDDS, TUG, BBS: $p < 0.0001$	Not reported	PDQ-39: 43.6 / 35.3 / 38.8; UPDRS: 39.6 / 27.2 / -; BBS: 46.8 / 52.5 / -	4 weeks; follow-up at 10 and 18 weeks

				UPDRS, PDDS, TUG, BBS improved. Levodopa dosage reduced.				
Sackley CM et al. (2020) [21]	NHS SLT, LSVT LOUD	VHI total score	PDQ-39, QASD, EQ-5D-5L, ICECAP-O	Both interventions improved outcomes over control.	$p < 0.01$	0.38	Not reported	3 months / 12 months
Levy ES et al. (2020) [7]	LSVT LOUD vs LSVT ARTIC vs No Treatment	Transcription accuracy (TA)	None reported	LSVT LOUD significantly improved intelligibility (TA +31.5%, $p < 0.0001$); ARTIC had non-significant improvement; No Treatment group declined.	Voice vs ARTIC: $p = 0.04$; Voice vs No Tx: $p = 0.0002$	Voice vs ARTIC: ES = 1.0; Voice vs No Tx: ES = 1.8	Voice: 53.6 / 85.1; ARTIC: 44.8 / 51.6; No Tx: 64.4 / 52.5	4 weeks; post-treatment follow-up (6-month data collected but not reported)
Brabenec L et al. (2021) [22]	rTMS over right superior temporal gyrus	Phonetics score (articulation, prosody, intelligibility)	Brain activation (fMRI), connectivity changes	rTMS improved phonetics scores vs sham; effects up to 8 weeks; enhanced	Time × group $p = 0.040$	Cohen's d = 1.391 (rTMS)	Phonetics score: Pre ~21 / Post ~23.5 / Follow-up ~24.5	10 sessions (2 weeks); follow-up at 2, 6, 10 weeks

				connectivity in motor speech regions.				
Maas JJL et al. (2022) [12]	Personalized speech therapy + Voice Trainer app via Telehealth	PDQ-39 summary index	Voice quality (Radboud Dysarthria Assessment), VHI, intelligibility, caregiver burden, mood/anxiety, swallowing	Ongoing study. Hypothesized improvements in speech intelligibility and QoL, maintained at 6-month follow-up.	Not reported	Not reported	Not reported	8 weeks; follow-up at 8 & 32 weeks
Mohseni Z et al. (2023) [23]	Combination therapy (speech + music), speech therapy, music therapy	Swallowing Disturbance Questionnaire (SDQ), Dysphagia Handicap Index (DHI)	DHI subscales (functional, physical, emotional)	Combination therapy was most effective. Music therapy improved emotional aspects more than physical.	$p < 0.05$	Not reported	SDQ (CT): 16.27→4.64→4.73; DHI (CT): 29.18→11.64→11.91; ST & MT scores similar trends.	12 sessions (4 weeks); 3-month follow-up
Maas JJ et al. (2024) [11]	Personalized remote speech therapy via Telehealth	PDQ-39 summary index	PDQ-39 communication, VHI, ROMP, MLL, DIT	Significant improvement in communication subdomain and VHI; no overall PDQ-39 improvement. VHI	PDQ-39 summary p=0.056 (NS); Communication p=0.011; VHI p=0.002	Not reported	PDQ-39: 28.5 / 24.7 / 26.6; ROMP Speech: 17.8 / 15.55 / 16.8; VHI: 35.9 / 30.9 / 32.0	8 weeks; follow-up at 32 weeks

				effect maintained at 32 weeks.				
Sackley CM et al. (2024) [8]	LSVT LOUD vs NHS SLT vs no SLT	VHI total score (3 months)	VHI subscales, QASD, PDQ-39, ICECAP-O, EQ-5D, PDQ-Carer	LSVT LOUD improved VHI at 3 months vs no SLT and NHS SLT. NHS SLT showed no benefit. LSVT LOUD continued benefit at 12 months.	LSVT LOUD vs no SLT: p<0.001; NHS SLT vs no SLT: p=0.43	VHI ES ~0.38	VHI: 44.6 / 35.0 / 38.2; PDQ-39: 27.9 / 27.6 / 28.5; QASD: 29.9 / 23.5 / 25.6	LSVT LOUD: 4 weeks; NHS SLT: 6-8 weeks; 12-month follow-up
Sackley CM et al. (2024) [18]	LSVT LOUD vs NHS SLT	VHI total score (3 months)	PDQ-39, QASD, EQ-5D-5L, ICECAP-O, PDQ-Carer	LSVT LOUD reduced VHI significantly at 3 months vs control and NHS SLT; sustained effects at 12 months. NHS SLT showed no benefit.	LSVT LOUD vs Control: p=0.0001; LSVT LOUD vs NHS SLT: p<0.0001; NHS SLT vs Control: p=0.4	VHI difference LSVT LOUD vs Control: -8.0 (99% CI: -13.3 to -2.6)	EQ-5D-5L: LSVT 0.637/0.605/0.590; VHI: LSVT 44.6/36.7/38.2; PDQ-39: LSVT 27.9/27.6/28.5	LSVT LOUD: 4 weeks; NHS SLT: 6 weeks; 12-month follow-up
Steuer H et al.	HiCommunication (group-	Voice sound level	AVQI, HNR	Significant improve	p = 0.003 (voice	Not reported	Voice Sound Level (Text	Group sessions;

(2024) [24]	based speech & communication training)	(text reading)		ments in voice sound level and voice quality post-intervention; no sustained effect at 6 months.	sound level), p = 0.016 (AVQI), p = 0.014 (HNR)		Reading): 70.8 / 73.0 / 70.4; Voice Sound Level (Monologue): 69.0... (truncated data)	follow-up at 6 months

Footnote: dB SPL: decibel sound pressure level; SP: speech pathologist

RESULTS

Table 1 summarizes 13 studies evaluating speech therapy interventions in Parkinsonism, including RCTs, experimental, and acoustic studies. A total of 2,377 patients were assessed, with sample sizes ranging from 28 to 546 participants. Patient ages varied from 58.9 to 71.7 years, with a male predominance of up to 74%. Most studies included individuals with idiopathic PD, Hoehn and Yahr stages 1 to 5, and dysarthria severity ranging from mild to severe. Interventions examined were LSVT LOUD, LSVT ARTIC, repetitive transcranial magnetic stimulation (rTMS), music therapy, and telehealth-based programs. Primary outcomes measured speech intelligibility, sound pressure level (SPL), and quality of life (QoL). LSVT LOUD consistently improved loudness and QoL versus standard or no treatment [6,7,8,18,21]. Telehealth delivery showed non-inferiority to in-person therapy [9,11,12,23,24].

Table 2 summarizes the key findings, outcome measures, and efficacy of speech therapy interventions in PD. Interventions included LSVT LOUD, LSVT ARTIC, clear speech strategies, rTMS, music therapy, multidisciplinary rehabilitation, and telehealth-based approaches. The primary outcomes were speech loudness, intelligibility, articulation, and quality of life (QoL). LSVT LOUD consistently improved speech sound pressure level (SPL), increasing monologue SPL from 69.6 dB to 77.1 dB ($p < 0.001$) [9,12]. Clear speech variants enhanced vowel space area and articulation rate, with effect sizes up to $\eta p^2 = 0.70$ [17]. Multidisciplinary programs reduced PDQ-39 scores by 8.3 points ($p < 0.0001$) [10]. Telehealth-delivered LSVT LOUD demonstrated non-inferiority to face-to-face interventions [9,11,12]. Voice Handicap Index (VHI) scores improved significantly post-LSVT LOUD, reducing by 8–9.6 points ($p < 0.001$) [7,8,18,21].

Table 3: Quality assessment done for the randomised control studies done using the Newcastle Ottawa Scale (NOS)

S. No	Study	Selection S1	S2	S3	S4	Comparability	Exposure E1	E2	E3	Total Score (Max 9 Stars)
1.	Theodoros DG et al. (2016) [9]	*	*	*	*	*	*	-	*	7

2.	Ramig L et al. (2018) [6]	*	*	*	*	**	*	*	*	9
3.	Ferrazzoli D et al. (2018) [10]	*	*	*	*	*	*	*	*	8
4.	Sackley CM et al. (2020) [21]	*	-	*	*	*	*	*	*	7
5.	Levy ES et al. (2020) [7]	*	*	-	*	**	*	*	*	8
6.	Brabenec L et al. (2021) [22]	*	*	*	*	*	*	*	*	8
7.	Maas JJL et al. (2022) [12]	*	*	*	*	**	*	*	*	9
8.	Mohseni Z et al. (2023) [23]	*	*	-	*	**	*	*	*	8
9.	Maas JJ et al. (2024) [11]	*	*	*	*	**	*	*	*	9
10	Sackley CM et al. (2024) [8]	*	*	*	*	**	*	*	*	9
11	Sackley CM et al. (2024) [18]	*	*	*	*	**	-	*	*	8
12	Steurer H et al. (2024) [24]	*	*	*	*	**	*	*	*	9

Table 3 presents the quality assessment of 12 RCTs using the NOS, with total scores ranging from 7 to 9 stars. Most studies demonstrated high methodological quality. 9 studies achieved 8 or more stars, including Ramig et al. (2018), Maas et al. (2022), and Steurer et al. (2024), each scoring the maximum 9 stars, indicating excellent selection, comparability, and outcome measures [6,11,12,24]. Theodoros et al. (2016) and Sackley et al. (2020) scored 7 stars due to limitations in comparability or exposure domains [9,21]. Consistency in selection criteria and exposure ascertainment was evident, ensuring the robustness of findings across the RCTs [7,8,10,18,22,23].

Table 4 details the quality appraisal of one quasi-experimental study, assessed using the JBI checklist. Lam et al. (2016) met 8 out of 9 quality criteria, indicating high methodological rigor [17]. The study adequately addressed participant selection, intervention clarity, outcome measurement, and statistical analysis. However, blinding was not reported, and one item was not applicable.

Table 4: Quality assessment done for quasi experimental study using the JBI tool for assessment

S. No	**Study**	**Question Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Total Score (Max 9 Stars)**
	Lam J et al. (2016) [17]	Yes	Yes	Yes	Yes	No	Not applicable	Yes	Yes	Yes	8 (high quality)

Figure 2 illustrates the individual risk of bias assessment for twelve RCTs using the ROB2 tool. The assessment covers five domains where most studies showed a low risk of bias in D2, D4, and D5, as indicated by green markers. However, concerns were identified in D1 and D3 in several studies, marked by yellow indicators. Specifically, Theodoros DG et al. (2016), Brabenec L et al. (2021), and Sackley CM

et al. (2024) had concerns related to randomization (D1) and missing data (D3). Overall, most studies demonstrated a low risk of bias, with concerns in specific domains.

Figure 2: Individual studies risk of bias assessment for RCT studies done using the ROB2 tool

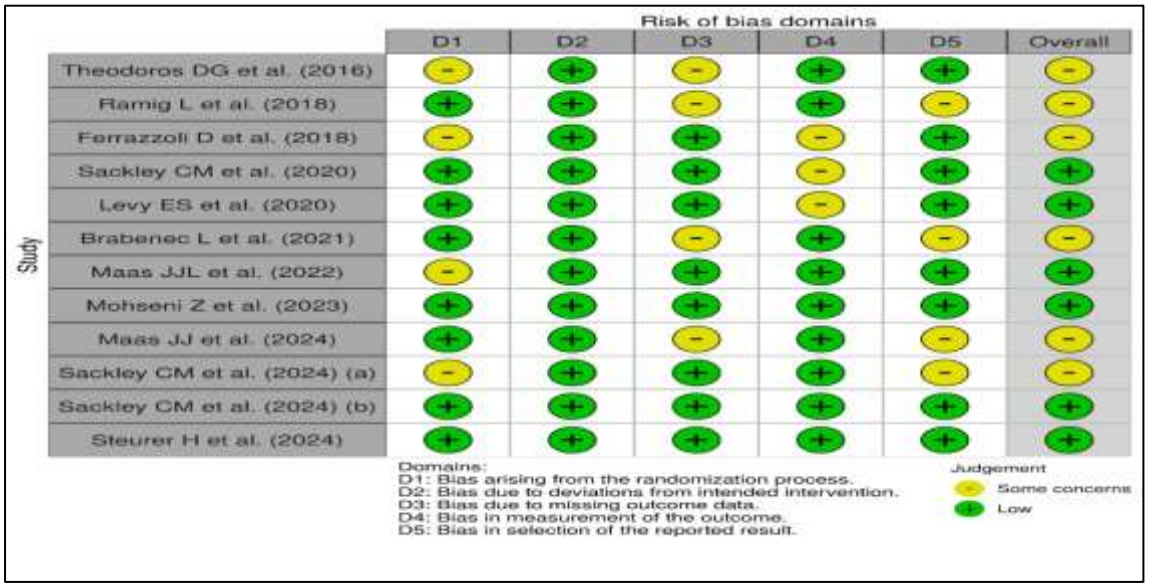

Figure 3 illustrates the overall risk of bias assessment for the included RCT studies based on the ROB2 tool. The bar chart summarizes the proportion of studies classified as low risk and those with some concerns in each domain. Approximately 50% of the studies show low risk in D1 (randomization), while the remaining studies have some concerns. In contrast, all studies show low risk in D2 (deviations from intended interventions). Domains D3 (missing outcome data), D4 (measurement of outcome), and D5 (selection of reported results) show higher proportions of studies with concerns, especially D3 and D5. Overall, more than half of the RCTs were assessed with some concerns, while the rest were classified as low risk.

Figure 3: Overall risk of bias assessment for RCT studies using the ROB2 tool

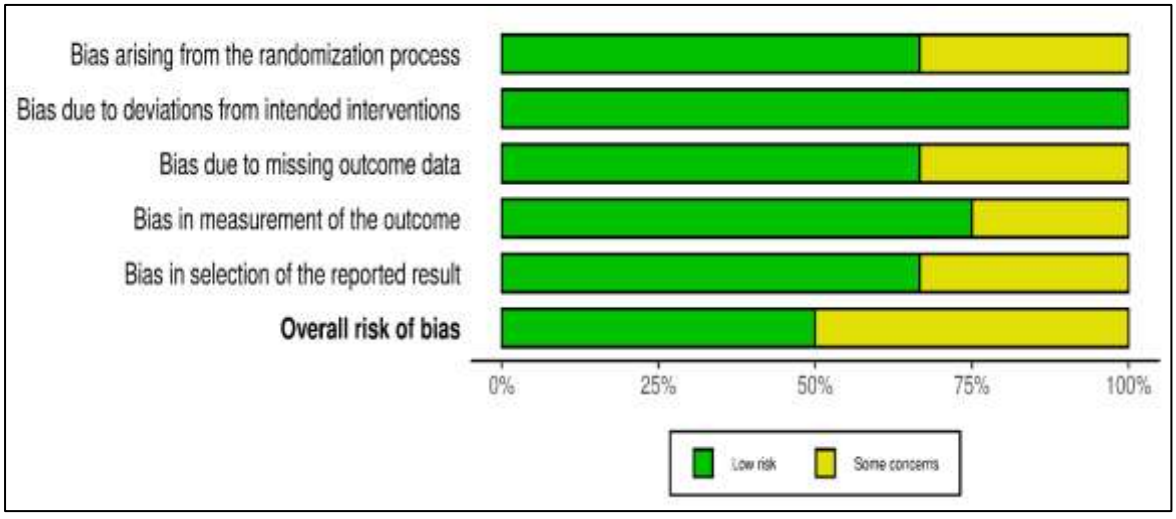

Figure 4 presents the individual risk of bias assessment for the quasi-experimental study by Lam J et al. (2016) [17], evaluated using the ROBINS-I tool across seven domains: D1 (confounding), D2 (selection of participants), D3 (classification of interventions), D4 (deviations from intended interventions), D5 (missing data), D6 (measurement of outcomes), and D7 (selection of reported results). The study shows

low risk in D1, D3, D4, and D5. However, D6 is rated as moderate risk, indicating concerns with outcome measurement, and D2 and D7 have no information, reflecting uncertainty in participant selection and reported results.

Figure 4: Individual studies risk of bias assessment for Quasi study using the ROBINS I tool

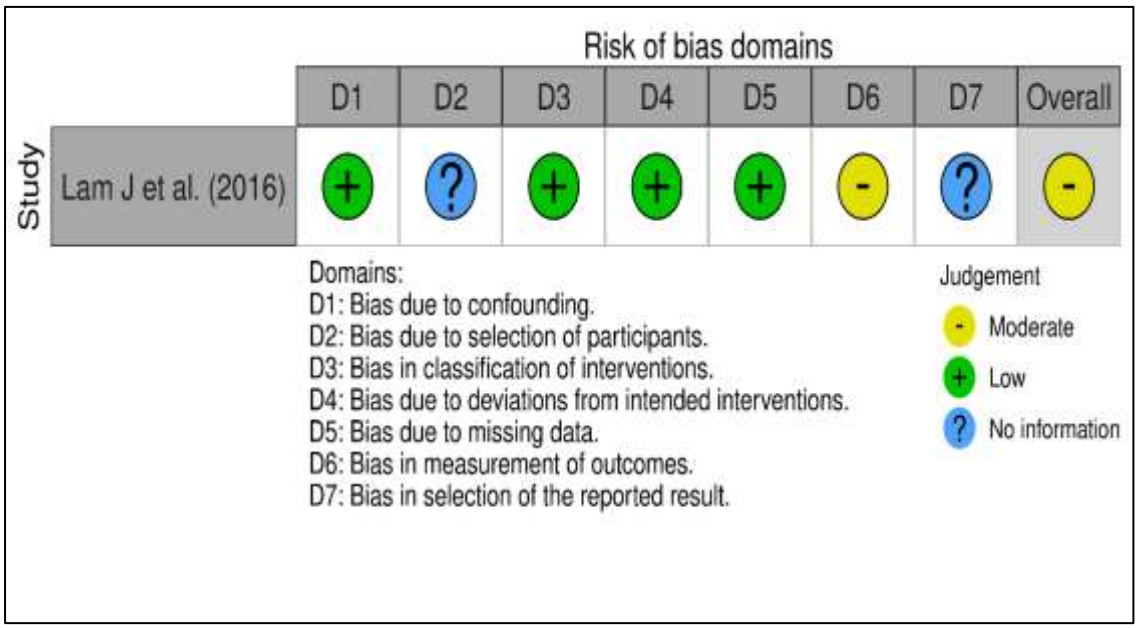

Figure 5: Overall risk of bias assessment for Quasi studies using the ROBINS tool

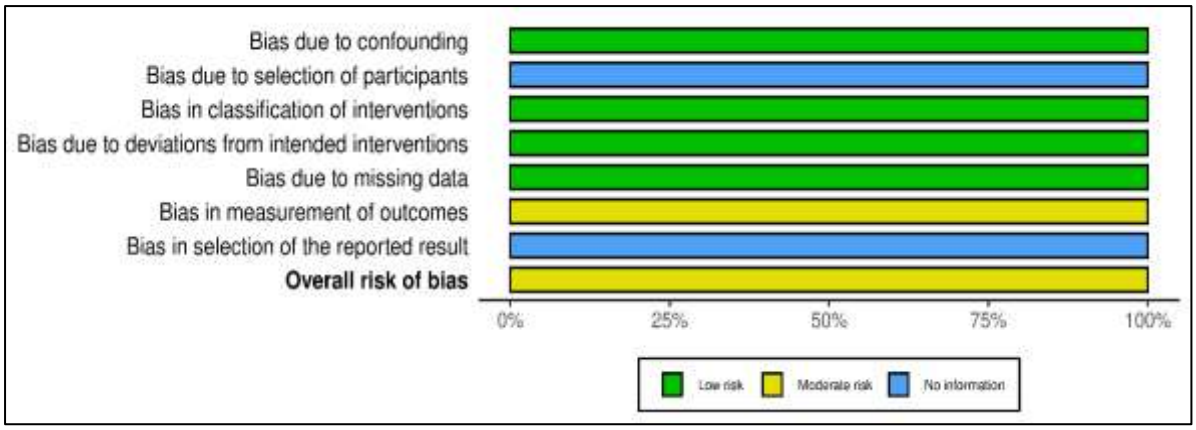

Figure 5 summarizes these findings, showing that while most domains indicate low risk, the study demonstrates a moderate overall risk of bias due to limitations in D6, D2, and D7.

DISCUSSION

PD is a progressive neurodegenerative disorder that impairs motor and non-motor functions, with hypokinetic dysarthria affecting up to 89% of individuals, reducing vocal loudness, pitch, and articulation [1,2,3,4]. This systematic review analysed 13 studies, including RCTs, prospective, and quasi-experimental designs, evaluating the effectiveness of various SLT interventions such as LSVT LOUD, LSVT ARTIC, and Muscle Intensive Respiratory Therapy (MIRT). The findings consistently support the efficacy of LSVT LOUD in improving speech outcomes, particularly vocal loudness and intelligibility [8,6,11,12,18].

Effectiveness of interventions:(RQ.1)

LSVT LOUD emerged as the most consistently effective intervention, with multiple RCTs showing significant gains in sound pressure levels (SPL) articulation, and speech intelligibility. [6,7,8,]. Improvements in vowel space area and articulation rate have also been reported, reflecting enhanced speech intelligibility [17,25]. Multiple RCTs and meta-analyses report significant gains in sound pressure levels (SPL), from 69.6 dB to 77.1 dB with face-to-face delivery [9]. LSVT LOUD outperforms LSVT ARTIC and NHS SLT, with an SPL effect size of 2.19 [6,18]. The underlying mechanisms of LSVT LOUD involve compensatory activation of neural pathways that address deficits in motor control caused by dopamine depletion, which contributes to hypokinetic dysarthria [3,5].

Randomized controlled trials confirm that remotely delivered interventions are non-inferior to face-to-face therapies in enhancing speech intelligibility, vocal loudness, and quality of life [9,11,29]. Besides, Tele-rehabilitation delivery of LSVT LOUD demonstrated non-inferior outcomes to in-person therapy, offering a feasible, effective option for patients with mobility limitations, geographic barriers and limited access to in-person services [11,12,26,27,28]. The PERSPECTIVE study supports personalized remote interventions aimed at improving conversational abilities [12]. Constantinescu et al. [23] validated telehealth delivery through a non-inferiority trial, showing sustained speech improvements. However, as novel interventions and technologies continue to emerge, there is a need for further research directly comparing the efficacy, long-term outcomes, and patient adherence of tele rehabilitation of LSVT LOUD with these newer approaches [7,24]. Such comparative studies would help determine the most effective and sustainable speech therapy strategies for individuals with Parkinsonism. While technological advancements offer real-time feedback and better adherence [9,29], heterogeneity in protocols and outcomes underscores the need for standardized methodologies in future studies [2,30].

Multi-modal rehabilitation strategies combining speech therapy with physical, occupational, and cognitive interventions show significant potential in improving communication and functional independence in individuals with PD [5,16,30]. Ferrazzoli et al. [10] reported notable QoL improvements, with PDQ-39 scores reduced by −8.3±18.0 ($p<0.0001$). These outcomes support previous studies emphasizing the importance of addressing both motor and non-motor symptoms in PD management [30,31]. Comprehensive programs incorporating rhythmic cueing, respiratory exercises, and cognitive training further enhance speech production and communicative effectiveness [5,16]. The addition of music therapy to speech-language therapy (SLT) has been associated with improved speech clarity and vocal loudness [32]. Neuroimaging studies suggest interventions like LSVT LOUD and HiCommunication promote neuroplasticity and strengthen neural connectivity [7,19]. However, heterogeneity in protocols and outcomes complicates comparisons, highlighting the need for standardized methodologies and long-term follow-up research.

Although LSVT LOUD consistently demonstrates superior improvements in vocal loudness and speech intelligibility in individuals with PD, alternative interventions like LSVT ARTIC, MIRT (Multidisciplinary Intensive Rehabilitation Therapy), and HiCommunication offer notable benefits in specific speech domains. LSVT ARTIC, emphasizing articulatory precision rather than vocal loudness, has been shown to improve speech clarity, although its effects on loudness and overall intelligibility are less pronounced compared to LSVT LOUD [6,33]. Similarly, Lam and Tjaden (2016) found that clear speech strategies, particularly the “overenunciate” condition, enhanced vowel space area and reduced articulation rate, but did not significantly improve vocal loudness in conversational speech [17]. HiCommunication, combining speech and cognitive training, demonstrated efficacy in maintaining communication abilities and cognitive performance over time in PD patients [22]. These findings highlight the importance of comprehensive, multi-modal interventions addressing PD’s complex speech impairments [5,10].

A key finding of this review is the sustained long-term benefits of LSVT LOUD. Several randomized controlled trials (RCTs) and longitudinal studies reported that improvements in vocal loudness, speech intelligibility, and communicative participation persisted for up to 12 months post-treatment [6,8,18].

These outcomes align with earlier findings by Ramig et al. (2008), who documented durable improvements in vocal loudness and intonation following LSVT LOUD [1]. Recent trials also demonstrated that telehealth-based delivery of LSVT LOUD yields comparable long-term outcomes to in-person therapy, making it a viable alternative when accessibility and adherence are concerns [11,9]. Beyond objective speech outcomes, studies have highlighted positive effects on quality of life. LSVT LOUD significantly reduced Voice Handicap Index (VHI) scores by 8 to 9.6 points compared to standard NHS speech-language therapy [8,18]. Additionally, multidisciplinary programs demonstrated improvements in PDQ-39 scores, supporting integrated care approaches [5,10,22,31].

Personalization of Therapy (RQ.2)

Personalized therapy is increasingly recognized as essential in PD care. Customizing treatment based on individual symptom profiles and disease progression has been shown to maximize treatment efficacy【4,6,9】Xu et al. [4], pointed out that by attending to the demands of each patient, customized treatment programs can maximize outcomes. Multi-modal approaches combining SLT with physical and occupational therapy offer a more holistic strategy to address the diverse impairments seen in PD【6】Research is still being done on the neurophysiological alterations brought about by therapies like LSVT LOUD, especially in respect to their association with long-lasting functional gains [7]. Tailored treatment strategies that consider each patient's unique demands and symptoms are crucial for optimizing results due to the diversity of Parkinson's disease and its unpredictable course [9]. The HiCommunication program, which integrates cognitive and speech training, reflects a promising direction in this domain【19】.

Differences in Protocols and Outcomes (RQ3)

Significant heterogeneity was observed in intervention protocols, therapy durations, and outcome measures across the studies. While LSVT LOUD typically followed a high-intensity, 4-week protocol, other interventions varied in frequency, duration, and delivery mode. Despite this, robust RCTs confirmed the efficacy of structured interventions over no treatment or sham therapy [10].

Techniques for remote rehabilitation, such SLT based on telehealth, have been investigated as substitutes for in-person therapy.The growing use of telehealth platforms enhances accessibility, particularly for rural or mobility-limited patients. Studies such as Maas et al. (2022) and the PERSPECTIVE trial demonstrate the effectiveness of remote interventions, though more research is needed to standardize protocols and assess long-term outcome. [11,12,14].

Strengths and Limitations: Most included RCTs were of high methodological quality, with 9 out of 12 achieving 8–9 stars on the Newcastle-Ottawa Scale. Robust study designs, including proper randomization and control groups, enhanced the reliability of findings. However, some concerns regarding randomization concealment and missing data were identified using the ROB2 tool. The quasi-experimental study by Lam and Tjaden (2016) had moderate risk of bias due to issues in participant selection and outcome measurement [17]. While the evidence strongly supports LSVT LOUD as a gold-standard intervention, the lack of standardized outcome measures remains a challenge for comparability. Furthermore, most studies focus on short-to-medium term outcomes, with few assessing real-world functional communication over longer durations. These findings align with earlier systematic reviews identifying LSVT LOUD as the most effective intervention for hypokinetic dysarthria in PD. This review further extends evidence by incorporating recent trials on telehealth and hybrid models, addressing accessibility gaps. Standardized outcome measures remain necessary to enhance comparability.

Future Directions: This review highlights key limitations in SLT research for hypokinetic dysarthria in PD. Variability in intervention protocols, therapy durations, and outcome measures complicates comparisons and underscores the need for standardization. Although LSVT LOUD shows sustained

benefits, further studies are necessary to confirm its long-term effects on functional communication in daily life. Moreover, emerging digital technologies and personalized, patient-centered interventions offer promising opportunities to improve adherence and outcomes, highlighting the need for comprehensive longitudinal and cost-effectiveness research.

CONCLUSION

Innovative approaches such as telerehabilitation, multimodal interventions, and technology-enhanced therapies present valuable opportunities to improve the accessibility and personalization of SLT for individuals with Parkinson's disease (PD). Despite these advancements, the current lack of standardization in intervention protocols and outcome measures limits the comparability of findings and underscores the need for consistent, long-term evaluations. Future research should emphasize patient-centered and individualized treatment strategies that address both the motor and non-motor components of communication impairment. Integrating pharmacological therapies with SLT may further optimize functional outcomes. Additionally, expanding the use of telehealth and digital platforms can help reduce access barriers, especially for underserved populations. Ultimately, clinicians should adopt comprehensive, tailored approaches to enhance adherence, therapeutic effectiveness, and overall health of individuals with PD.

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