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REVIEW

Parkinson's disease-associated dysarthria: prevalence, impact and management strategies

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Abstract: Dysarthria is a motor speech disorder of neurological origin and is characterized by deficits in the execution of movement for speech. Close to 90% of individuals with Parkinson's disease (PD) present with hypokinetic dysarthria, as evidenced by reduced vocal loudness, monotone, reduced fundamental frequency range, consonant and vowel imprecision, breathiness and irregular pauses. The presence of these speech deficits negatively impacts intelligibility, functional communication and, ultimately, social participation. The aims of this review are to 1) describe the nature of this motor speech disorder and its impact on the ability to communicate effectively, 2) provide an overview of medical approaches to dysarthria management and 3) review research on behavioral treatment techniques aimed at improving the intelligibility and quality of life of individuals with dysarthria secondary to PD. The delivery of speech treatment through telepractice is also examined, as this is a modality particularly well-suited to individuals with the mobility difficulties characteristic of PD. Finally, dysarthria management across languages is considered, representing a relevant new and under-researched area in motor speech disorders.

Keywords: Parkinson's disease, motor speech disorders, dysarthria, speech therapy

Video abstract

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Introduction

Parkinson's disease (PD) is the second most common neurodegenerative disease following Alzheimer's disease[1] and affects over six million people worldwide.[2] In the United States, approximately one million individuals are estimated to suffer from this disease, considered the 14th leading cause of death in the country.[3] Although PD is usually developed between the ages of 55 and 65, with an average disease duration of 10 years,[4] the onset of the disease may start before the age of 40.[5] With the world population growing and longevity increasing, the need for treatment research on motor speech disorders is also on the rise.[6]

The aims of this review are to 1) describe the nature of hypokinetic dysarthria, the motor speech disorder associated with PD and its impact on the ability to communicate effectively, 2) provide an overview of medical approaches to dysarthria management and 3) review research on behavioral treatment techniques aimed at improving the intelligibility and quality of life of individuals with dysarthria secondary to PD (henceforth, individuals with PD). Crosslinguistic considerations in dysarthria treatment research are discussed. This overview is not intended to be an exhaustive review of the literature, but rather to report on findings in treatment research in PD and to consider their implications for clinical practice.

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Hypokinetic dysarthria due to PD

Hypokinetic dysarthria results from dysfunction in the basal ganglia motor loop,[7] which causes deficits in the regulation of initiation, amplitude and velocity of movement. This type of dysarthria is characterized by reduced vocal loudness, monotone, reduced fundamental frequency range, consonant and vowel imprecision, breathiness, short rushes of speech and irregular pauses.[8,9] Close to 90% of individuals with PD experience voice disorders, while 45% experience articulation problems and 20% experience fluency disorders.[10,11] Although voice disorders may be the primary concern regarding speech production in the early stages of the disease, disfluency and articulation impairments also emerge as the neurodegeneration progresses, with motor control deficits affecting articulation exerting the greatest negative impact on communication in the final stage of the disease.[10]

Physiologically, hypokinetic dysarthria is associated with poor breath support and reduced range of motion of the speech articulators,[12,13] contributing to perceived undershoot of target sounds.[14] These acoustic-perceptual and physiological characteristics, therefore, have a detrimental effect on the individuals' intelligibility and, hence, their ability to communicate effectively. Of note, however, in an examination of the perspective of individuals with PD on changes in their communication, Miller, Noble, Jones and Burn found that even before intelligibility issues arise, the individuals experience negative consequences of early changes in voice quality and decreased control of their speech output.[15] While they are usually able to modify their speech for short periods of time, their concerns are less about the changes themselves (eg, decreased control of pitch) than about the impact these changes have on their self-image and their communication, and their embarrassment when their speech output is not what they intended. Moreover, the frustration and effort needed to overcome their communicative limitations can result in social withdrawal. The authors conclude that early referral of newly diagnosed individuals with PD should be the norm, rather than referrals being delayed until frank deficits in intelligibility become evident.

Although the motor speech disorder of dysarthria is a primary communication complaint of individuals with PD, it is worth noting that other aspects of communication are also affected. For example, difficulties with lexical retrieval and comprehension of figurative language have been reported,[16] as well as with grammaticality, syntactic complexity and information content.[17] Beyond the linguistic domain, the presence of hypomimia, a reduction in facial expression, also limits these individuals' communicative interactions, social participation and the quality of their relationships with their care partners.[18]

Pharmacological management of dysarthria due to PD

Pharmaceutical and surgical management are approaches frequently called upon for treatment of motor symptoms of PD. However, these have shown less success in alleviating symptoms of dysarthria than has behavioral management. Levodopa, the precursor of the neurotransmitter dopamine, is the first medicine typically used in the clinical management of PD. The use of levodopa and dopamine agonists to treat motor symptoms such as tremors in PD is strongly supported by scientific evidence across all stages of the disease.[19] However, pharmacological management of dysarthria is less straightforward.[20] Early pharmacokinetic studies on the effects of levodopa medication on speech function revealed trends toward improvement during the ON phase of medication.[21] Ho, Bradshaw and Iansek studied the effects of levodopa medication on the speech of nine individuals with idiopathic PD and observed an increase in sound pressure level (SPL, the acoustic correlate of vocal loudness) in the ON phase,[22] which was consistent with some previously reported findings,[23] but contrasted with an absence of positive response to levodopa to ameliorate hypophonia found in other studies,[24,25] suggesting heterogeneity of individual profiles influencing outcomes. Ho et al also observed an increase in speaking rate as a result of levodopa medication, consistent with the upscaling of gain noted for limb movements.[22] Fundamental frequency and articulation, however, remained unchanged.

A reduced effect on brain activation patterns involved in the production of speech has also been found following levodopa medication.[26] A recent study of levodopa effects on speech and voice in 24 individuals in the late stage of the disease (ie, with a Schwab and England score of <50 or a Hoehn and Yahr stage >3 while on medication) found no improvements in speech in response to this medication.[12] Thus, current evidence suggests limited and variable success in response to pharmacological treatment of dysarthria, leading to clinical reliance primarily on behavioral management strategies.

Surgical management of dysarthria

Like pharmacological management, surgical management in PD has generally not yielded positive outcomes for dysarthria. Deep brain stimulation involves electrode implantation surgery in specific areas of the basal ganglia.[27] This surgical procedure has been reported as an effective treatment option for motor symptoms such as dyskinesias in PD in several randomized controlled trials (RCT);[28–30] however, its adverse effects on speech have been consistently reported in the literature.[31–36] Other surgical procedures have also been associated with a deterioration of speech. For example, in thalamotomies, a lesion is made in the thalamus with the goal of improving tremors. Thalamotomies have been reported to produce hypophonia, reduce speaking rate and lead to word blocking.[37,38] This procedure is even thought to have resulted in some cases of palilalia.[39] Consequently, thalamotomy has been abandoned as a treatment option for PD.[20] Similarly, pallidotomy, in which a heated electrical probe is inserted in the globus pallidus, destroying a small region of cells in order to alleviate dyskinesias, has not been found to be conducive to improvement in dysarthric speech.[20] In fact, it has been associated with the development of verbal fluency deficits, swallowing difficulties and facial weakness.[40]

Behavioral management of dysarthria

In part because of the poor outcomes for speech of pharmaceutical and surgical management of PD symptoms, dysarthria management has come to rely on behavioral approaches. Fortunately, behavioral approaches have resulted in more positive outcomes, including clinically meaningful changes revealed in RCTs.

Speech cueing studies

Two types of clinically relevant research, speech cueing studies and speech treatment studies, aim to shed light on effective behavioral approaches to dysarthria management. We discuss speech cueing studies first, in which investigators provide speech cues such as "loud" or "slow" or "clear" and compare effects of these cues on acoustics and/or intelligibility of dysarthric speech. For example, Tjaden and Wilding found support, in particular, for cueing for loud speech in their examination of the effects of speech cues on the acoustics and intelligibility of utterances produced by 15 individuals with multiple sclerosis (MS) and 12 individuals with PD.[41] Findings from the PD group indicated that when instructed to use speech that was twice as loud as their usual speaking voice, half of the individuals improved consonantal distinctiveness for stop consonants. Listeners' ratings of intelligibility also increased in the loud condition, suggesting a beneficial effect of increasing loudness on perceived intelligibility, consistent with the intelligibility benefits documented for amplified speech.[42]

A slower-than-normal speaking rate has been hypothesized to increase the precision of consonantal articulation, phoneme duration and vowel working space, as well as to reduce lexical boundary errors, contributing to the reduction of phonemic and lexical ambiguity experienced by listeners.[43] Nonetheless, cueing for slow speech appears to be a less effective strategy for increasing intelligibility in dysarthria than is cueing for loud speech, likely because slowing speech rate limits dynamic formant frequency changes,[44] negatively impacting speech naturalness and, therefore, intelligibility. Not surprisingly, Tjaden and Wilding reported greater intelligibility ratings for speech in their loud condition than in their slow or habitual condition.[41]

Clear speech, in contrast, is characterized by exaggerated articulation,[45] with concomitant prosodic changes such as increases in vocal intensity and reduction in speaking rate.[46] Cueing for clear speech may involve instructing individuals to speak clearly or to use speech that is twice as clear as their usual speaking voice. Tjaden, Sussman and Wilding compared the effects of cueing for clear, loud or slow speech on scaled intelligibility in 30 individuals with MS and 16 individuals with PD.[45] Only the clear and loud speaking styles were found to improve intelligibility (in both groups of individuals), suggesting promise for these two techniques for enhancing communication in individuals with dysarthria.

Speech treatment studies

Unlike speech cueing studies, speech treatment studies examine changes from performance at baseline to performance following treatment. During testing, speakers are not provided with any speech cues. Thus, any gains in performance represent learned behaviors rather than immediate responses to cues. Traditional behavioral treatment for dysarthria addresses all speech subsystems: respiratory drive, phonation, articulation, prosody and resonance.[47] Immediately following such subsystem treatments, positive results have been found with the more intensive treatment protocols.[48]

Speech treatments with a specific speech subsystem target, rather than targeting multiple subsystems, have also been developed for hypokinetic dysarthria, with varying degrees of success. These primarily include focus on increased vocal loudness or articulatory working space,[49,50] although other speech subsystems have also been explored, as described in the following section.

Respiratory treatment has been implemented in the management of dysarthria, with variable success. The aim of this therapeutic approach is to increase respiratory support in order to produce sufficient subglottal air pressure for speech.[47] Posture control is one of the key characteristics of behavioral respiratory treatment for dysarthria. Positioning individuals in supine or prone positions is thought to increase their subglottal air pressure (thus increasing their vocal intensity).[51] Despite the importance of adequate respiratory support for speech, respiratory treatments alone have not yielded statistically significant improvement in vocal function in dysarthria.[52]

Another treatment target that has been examined is resonance. For example, Wenke, Theodoros and Cornwell studied ten individuals with velopharyngeal incompetence (VPI) and nonprogressive dysarthria secondary to PD, who were randomly assigned to either a traditional (TRAD) treatment group or an intensive voice-focused group.[53] While the traditional treatment group focused on exaggerated articulation, oromotor exercises within speech tasks, breathing, resonance and prosody, the voice-focused group focused on increasing SPL and fundamental frequency range with a regimen of high-intensity exercises. Trends toward decreased hypernasality immediately after treatment were found in the voice-focused group, suggesting potential for a voice-focused approach for improving velopharyngeal function in PD.

With its respiratory–laryngeal subsystem target of voice, the Lee Silverman Voice Treatment (LSVT LOUD) is the only speech treatment with Level I evidence for improving vocal function in PD.[54] This program elicits maximum vocal effort during sustained phonations, maximum frequency range exercises and functional speech tasks and is designed to increase subglottal air pressure, improve vocal fold adduction and articulatory movements and enhance vocal tract configurations.[49,54] LSVT LOUD is based on principles of motor learning, primarily repetition, intensity, specificity and saliency, believed to enhance neural plasticity through an acquired habit of motor routines.[55–57]

Ramig et al compared the voice-focused LSVT LOUD with an intensive respiratory (RES) treatment in a RCT of a group of 45 individuals with PD (33 males and 12 females).[58] While LSVT LOUD focuses on the single target of voice to address the respiratory and phonatory subsystem deficits that are characteristic of dysarthric speech,[49,58–60] the intensive respiratory treatment was designed to maximize inspiration and expiration and achieve increased volume of subglottal air pressure. Visual feedback on breathing patterns was provided to participants during some of the tasks. Statistically significant improvements pre-to-post treatment were found in both (LSVT LOUD and RES) groups for various measures, such as conversational SPL and perceptual self-ratings of monotonicity. However, overall, LSVT LOUD yielded a more consistent and greater increase in fundamental frequency variation and vocal intensity, and individuals who received LSVT LOUD also reported a reduced impact of PD on their communication.

Several physiological benefits have been associated with LSVT LOUD, such as vocal quality and articulation,[61,62] increased fundamental frequency range (ie, prosodic inflections) and enhanced resonance.[49] Recently, an RCT with 64 individuals with PD compared SPL across three groups: LSVT LOUD, LSVT ARTIC (an intensive treatment protocol targeting articulation through increased movement amplitude of the speech articulators) and an untreated subset of individuals with PD. Results from this RCT showed significant increases in SPL in the individuals in the LSVT LOUD group at 1 and 7 months post-treatment, compared to those in the LSVT ARTIC and untreated groups.[63] Furthermore, although the speakers in both treated groups obtained higher Modified Communication Effectiveness Index scores at 1-month post-treatment, only the individuals in LSVT LOUD maintained treatment effects on their overall communication ratings at the 7 months follow-up, suggesting a prolonged benefit for SPL and overall communicative effectiveness of intensive speech treatment targeting voice.

Speech intelligibility, too, has generally shown gains following LSVT LOUD. For example, significant intelligibility increases have been reported post-treatment at the sentence level in stimuli presented to naïve listeners at equalized intensity levels and in competing noise.[64,65] Additionally, Ramig, Countryman, Thompson and Horii found significant improvements in pre-to-post ratings of overall intelligibility (by individuals with PD and their families)[58] following this voice-targeted treatment (but see studies by El Sharkawi et al and Ramig et al).[66,67] Moreover, in a recent RCT comparing LSVT LOUD, LSVT ARTIC and an untreated group, ease of understanding ratings by 117 listeners increased with both experimental treatments, but not for the untreated group. The more rigorous intelligibility measure of transcription accuracy increased significantly for LSVT LOUD, but not for LSVT ARTIC, providing stronger support for the voice-targeted approach.[68]

The intensive schedule of 4 days of treatment for 4 weeks required by the LSVT LOUD protocol may not be feasible in many treatment settings. Thus, treatment studies with adaptations to the schedule have also been conducted in English and in other languages, yielding positive results. LSVT-X involves treatment twice a week for eight consecutive weeks, following the hierarchy and tasks established in LSVT LOUD.[69] Significant increases in SPL have been found following LSVT-X, as well as significant improvements in judgments of vocal quality, speaking rate, intonation, naturalness and articulatory clarity in individuals with PD. LSVT-X was implemented in a study of the effects of pharmaceutical and speech treatment on prosody in 10 Brazilian-Portuguese–speaking individuals with PD.[70] The results were optimal for participants who were tested while taking levodopa. After sixteen 50-min sessions twice a week, the participants revealed increased fundamental frequency and intensity and reduced utterance duration, suggesting that a modified schedule of intensive vocal exercises may also lead to acoustic benefits.

For similar scheduling reasons, as well as for ease of access, adaptations to the delivery modality of LSVT LOUD have also been implemented, with positive results found with the use of teletherapy techniques. Teletherapy approaches using LSVT LOUD range from the use of videophones and videoconferencing through Skype to more sophisticated techniques that allow for the precise measurement of SPL, fundamental frequency and duration.[71–73] Findings from a randomized controlled noninferiority online trial showed comparable results between the traditional face-to-face LSVT LOUD protocol and its online version, providing clinical validity of the online modality for speech rehabilitation in individuals with PD.[74]

Augmentative and alternative communication

Beyond treatment retraining speech production in adults with PD, the use of augmentative and alternative devices may be implemented to enhance overall communication.[47] Helm investigated the effects of using a pacing board for 2 weeks on the speaking rate of a single individual with postencephalitic Parkinson syndrome and concluded that this method was effective in reducing speech rate and eliminating palilalia.[75] Similarly, Downie, Low and Lindsay found positive effects of a portable delayed auditory feedback device on reduction of speaking rate in 2 individuals with PD (out of 11); however, the learned skill did not generalize without the use of the device; thus, the individuals needed to rely on its continued use to maintain the benefits.[76]

Dysarthria management beyond the individual: group therapy approaches

Group treatment is also often implemented in university clinics and beyond, with the aim of improving speech communication in PD in a larger, supportive setting. De Angelis et al investigated the effects of 13 group therapy sessions on voice variables in 20 individuals with PD.[50] Treatment focused on increasing phonatory function through the implementation of a high-effort program based on pushing exercises during phonation, as well as overarticulation techniques to maximize articulatory precision. Positive changes following speech treatment were reported, indicating greater laryngeal efficiency. Specifically, the study reported an increase in maximum phonation times and vocal intensity, a decrease in *s/z* ratio measures and a reduction in self-perceived deviant vocal characteristics (eg, monotone or strained-strangled voice quality). An improvement in speech intelligibility was also found as measured by participants' self-evaluations, suggesting promise for such group treatment.

Crosslinguistic research on speech treatment for PD

Most of the studies described above, as well as the vast majority found in the literature, report on outcomes of American English-speaking individuals with PD. Despite the estimated prevalence of over six million individuals with PD worldwide, little research has been conducted on speech treatment for PD in languages other than English. In a study of Spanish speakers with PD, Moya-Galé et al investigated the effects of LSVT LOUD on conversational intelligibility and self-perceptions of daily communicative capabilities.[77] Subjective and objective intelligibility measures (including the rigorous intelligibility measure of listeners' orthographic transcription accuracy) revealed substantial and significant gains in both variables post-treatment. These findings, therefore, support the implementation of this intensive treatment approach in Spanish-speaking populations and raise the question of whether vocal loudness increases conversational intelligibility universally.

Acoustic studies of the effects of voice-targeted treatment in languages other than English have also been conducted. Whitehill, Kwan, Lee and Chow investigated the effects of LSVT LOUD in 12 Cantonese-speaking individuals with PD.[78] Results revealed significant improvements in both vocal loudness and intonation. However, lexical tone was relatively intact, as measured by tone acoustics (ie, fundamental frequency configurations) and perceptual analysis (ie, listeners' transcription of isolated syllables and identification of error tones in phrases). This outcome is in contrast to the well-documented deficits experienced by individuals with PD at the laryngeal level.[79,80] Significant acoustic changes at the segmental level pre-to-post treatment (eg, increased vowel duration and increased vowel space area) have been also reported in other languages (eg, Quebecois French) following an intensive voice-based treatment.[81] These findings are in agreement with previously reported results in the English literature.[82] The similarities in intelligibility gains as a result of increased vocal effort in English and Spanish, as well as the observed increases in vowel space in English and Quebecois French, post-treatment, are preliminary evidence of potentially language-universal effects of treatment, warranting further investigation. Language-specific constraints of treatment still remain largely unexplored, but differences in articulation and prosody across languages are likely to render differential effects of treatment in PD.[83] We maintain that it is of utmost clinical importance for further research to address questions of whether any speech treatment benefits in individuals with PD might be 1) universal, regardless of their language background or 2) constrained by language-specific characteristics.

Conclusion and future directions

The motor speech disorder of dysarthria can have devastating effects on communication in individuals with PD, but progress in behavioral management strategies has continued to improve speech production in this population. Larger RCTs and implementation research in clinical settings across languages are expected to provide important details on and fine-tuning of effective treatment strategies for improving intelligibility, social participation and quality of life in individuals with dysarthria due to PD worldwide. Emerging research on benefits of speech treatments for hypokinetic dysarthria in different languages will contribute to better serving this growing linguistically diverse clinical population.

Disclosure

The authors report no conflicts of interest in this work.

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