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Behavioral Management of Respiratory/Phonatory Dysfunction From Dysarthria: A Systematic Review of the Evidence

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This systematic review of the literature addresses behavioral techniques for the management of respiratory/phonatory dysfunction in dysarthria. It was carried as part of the development of practice guidelines for the Academy of Neurologic Communication Disorders and Sciences (ANCDS). A search of electronic databases (PsychINFO, MEDLINE, and CINAHL) and hand searches of relevant edited books yielded 35 intervention studies in the categories of biofeedback, device utilization, the Lee Silverman Voice Treatment (LSVT), and several miscellaneous studies. A review of this literature suggests that biofeedback can be effective in changing physiologic variables. However, the relationship between changes in specific physiologic variables and speech production or communicative participation has yet to be clearly established. Conclusions about the effectiveness of devices are limited by the small number of subjects studied; however, the devices may improve the speech loudness and, in most cases, intelligibility of individuals with hypokinetic dysarthria who have not experienced success with behavioral

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intervention alone. LSVT has been systematically studied in a relatively large number of individuals with idiopathic Parkinson disease. There is strong evidence to suggest immediate posttreatment improvement; there is some evidence of long-term maintenance of effect, but the data are complicated by the expected neurologic deterioration in this population and by the small number of studies that report long-term follow-up. Directions for future research are provided.

In 1997, the Academy of Neurologic Communication Disorders and Sciences (ANCDS) established a committee, including the authors of this report, to develop practice guidelines in dysarthria (Spencer et al., 2002; Yorkston, Spencer, Beukelman et al., 2001; Yorkston, Spencer et al., 2001b). Clinical practice guidelines are explicit descriptions of how patients should be evaluated and treated. Their purpose is to improve the quality of care and to assure quality by reducing variation in care. As part of the development of practice guidelines, systematic reviews of intervention studies are carried out (Yorkston, Spencer et al., 2001a). The purpose of this article is to report the results of a systematic review of intervention literature related to behavioral techniques for the management of respiratory/phonatory dysfunction in dysarthria.

METHODS

The procedures used in this review are typical of those employed in the development of practice guidelines. They are discussed in more detail elsewhere (Yorkston, Spencer et al., 2001a).

The Searches

The following electronic databases were searched: PsychINFO covering 1,300 journals (1967 to June, 2001), MEDLINE covering 3,900 journals (1966 to June, 2001), and CINAHL covering 600 journals (1982 to June, 2001). The initial searches were keywords paired with the term dysarthria, for example, Dysarthria and Respirat* (note: an asterisk is used to search for all terms that begin with the letters preceding the asterisk), Dysarthria and Breathing, Dysarthria and Pulmonary, Dysarthria and Voice and Therapy, Dysarthria and Voice and Treatment, Dysarthria and Phonat*, and Dysarthria and Vocal. Other searches included Voice Treatment, Phona* and Disorder and Therapy, Dysphonia and Management, and Dysphonia and Speech Therapy.

In addition to electronic searches, hand searches of relevant edited books in the field of dysarthria and ancestral searches of extant references (e.g., studies cited within an article or chapter) were conducted. The general search on the topic of dysarthria yielded 2,792 references. From this large corpus, references related to behavioral intervention for respiratory and phonatory dysfunction were selected. Intervention studies were defined as those focusing on treatment of the respiratory or phonatory system for at least one person with dysarthria. Thus, articles were excluded that

1. described but did not treat respiratory/phonatory function in dysarthria,
2. applied treatment approaches to individuals without impairment,
3. studied techniques for management of respiratory/phonatory impairment associated with disorders other than dysarthria, for example, behavioral management of vocal nodules, psychogenic, or musculoskeletal tension dysphonia, and
4. did not involve behavioral intervention, for example, electrical stimulation of the respiratory muscles, vestibular stimulation, postural adjustment, surgical or pharmacologic intervention.

Intervention studies that focus on prosodic aspects of speech production (e.g., enhancing stress patterning through pitch modulations) are reviewed in the module, "Enhancing Speech Intelligibility and Naturalness." Review articles and chapters that survey intervention approaches are not included in this systematic review but serve as supportive documentation for a companion article (Spencer, Yorkston, & Duffy, 2003).

Panel of Expert Reviewers

A draft of this report was made available to a panel of expert reviewers. The technical report was reviewed by 17 experts in addition to the writing committee. A majority of these individuals hold doctoral degrees. Although most of the expert reviewers were members of ANCDS, the opinion of reviewers from outside the organization's membership with known expertise on respiratory/phonatory function was also sought. The comments of the expert reviewers were carefully considered and used to modify the technical report. Finally, the report was distributed in the form of both a technical report (available on the websites of ANCDS http://www.duq.edu/ancds/ and American Speech-Language-Hearing Association (ASHA) http://www.asha.org/) and the clinically focused companion articles in this issue.

Rating of the Strength of Evidence

The strength of evidence in each article was rated according to a framework adapted from the American Psychological Association (Chambless & Hollon, 1998). Tables of evidence were constructed that list the studies in chronological order and contain a rating of the strength of evidence for each study (Tables 1 to 3). In addition to the type of study, a description of the primary focus of the particular intervention approach is provided. Also included are select subject descriptors indicating the number of subjects, type of dysarthria, and medical diagnosis. The replicability of each study also was rated. An intervention technique was considered replicable if a knowledgeable person could duplicate the treatment. To meet this criterion, one of the following must have been provided in the article:

1. information regarding a procedural manual,
2. an available reference for the treatment procedure, or
3. a sufficiently detailed description of the methods, including specifics about the intensity and frequency of treatment.

Articles that did not meet these criteria were rated as either moderate or low in terms of replicability. The psychometric adequacy of measurement was assessed by indicating whether information was provided regarding reliability and stability of the measurement of the outcomes; for example, inter- or intrarater reliability, dispersion of judges' scores, and comparison of measures to a gold standard were all considered evidence of psychometric adequacy. Additionally, a summary of the evidence for control was recorded for each study. This summary described why the changes noted in the study could be attributed to intervention and not to other variables. The outcome measures used for each study were reported for the impairment level and for the level of activity limitations/participation restrictions (*International Classification of Function, Disability and Health*, 2001). Study conclusions were also summarized.

RESULTS

A total of 35 intervention studies reporting the effectiveness of behavioral intervention for respiratory/phonatory dysfunction have appeared during the last 20 or more years. These studies were identified, obtained, and rated by the authors. See Table 4 for a timeline of publication of these studies. Note that the majority of these studies have been published since 1990. Intervention studies focusing on behavioral management of respiratory/phonatory dysfunction were grouped into four categories. Various forms of physiologic intervention, most involving *biofeedback* of physiologic information (i.e., intraoral air pressure, chest wall movements, volume, pitch), were used in 11 studies. Six studies reported the use of *devices*, specifically, delayed auditory feedback (DAF), voice amplifiers, and a masking device. Another 16 studies of the Lee Silverman Voice Treatment (LSVT) were conducted. Finally, the category of *miscellaneous* interventions ($n = 4$) included, for example, a study of behavioral therapy in conjunction with Botox injection for spasmodic dysphonia and group therapy studies.

Table 5 summarizes the experimental design for the four categories of intervention focus. The table shows that treatment studies reporting biofeedback of specific physiologic parameters tended to use case, case series, or single case designs. Studies of the use of devices were often case studies or series of cases. In contrast, a substantial number of group studies with control subjects were reported for LSVT. As is typical in other areas of intervention, early studies of LSVT were case reports, and later studies involved larger groups with various types of experimental control. The following sections contain a detailed summary of each type of intervention.

Biofeedback Studies

Various types of physiologic interventions using biofeedback were the primary form of treatment in 11 studies (see Table 1). Biofeedback is "a process of transducing some physiologic variable, transforming the signal to extract useful information, and displaying that information to the subject in a for-

TABLE 1. Table of evidence summarizing biofeedback intervention studies.

Reference	Type of Study	Primary Focus	Number of Subjects	Type of Dysarthria	Medical Diagnosis	Replicability	Psychometric Adequacy
Netsell & Daniel (1979)	case	Pressure biofeedback program	1	flaccid	TBI	high	present
McNamara (1983)	case	Hypertonic exercises; biofeedback	1	flaccid	CVA	moderate	absent
Scott & Caird (1983)	group with controls	Prosodic exercises with & without visual feedback	26	not specified	PD	moderate	present
Rubow & Swift (1985)	single subject design	Portable biofeedback device to facilitate generalization of improved respiratory control	1	not specified	PD	moderate	present
Simpson, Till, & Goff, (1988)	case	Abdominal binder, biofeedback program to improve respiratory support, voice amplifier	1	not specified	Basilar artery thrombosis	moderate	present
Daniel-Whitney (1989)	case	Biofeedback of intraoral air pressure	1	spastic-ataxic	TBI	moderate	present

Evidence for Control	Measures of Impairment	Measures of Activity or Participation	Study Conclusions
Patient was beyond the period of spontaneous recovery. Baseline performance (2 sessions) reported; maintenance observed	Estimation of subglottal air pressure (cm H_20/sec)	Anecdotal information suggested overall improvement allowed patient to independently operate a service station	After 8, 20-minute treatment sessions, patient moved from generating 2–3 cm H_20 for < 3 sec to 10 cm H_20 of subglottal pressure for 10 sec.
Limited	Changes in intensity & duration of vowel phonation; perceptual improvement in loudness		Biofeedback treatment, in conjunction with oral-articulatory management, resulted in increased vocal loudness.
Random assignment of patients to two treatment groups (prosodic exercises with or without visual reinforcement)		Perceived abnormality of prosody as judged by tape-recorded test and spontaneous speech samples. Perceived intelligibility on a scale of 0–3. Patient's relatives were asked to comment.	Significant improvements in prosodic abnormality and intelligibility, maintained in part for up to 3 months. Visual reinforcement device produced limited benefit over prosodic exercises alone.
Comparison of Phase 1 treatment (no feedback from device) with Phase 2 (feedback from device). Speech improvement while PD progressed	Perceptual analysis (modified version of the 7-point, 38-dimension rating scale) & acoustic analysis of conversational & reading. Vocal intensity probes outside clinic		Subject transferred substantial portion of clinic improvement to outside environment while wearing feedback device and improved perceptually (on 8–9 out of 12 dimensions) and acoustically
Measurements documenting improvement taken with & without abdominal binder, and with & without voice amplifier. Measurements were documented over time	Forced vital capacity on spirometer; oscillographic spirometer; post-biofeedback forced vital capacity. Speech intensity with & without abdominal binder and voice amplifier	Amplifier allowed patient to speak for a longer period of time without fatigue	Abdominal binding increased speech intensity & vital capacity. Biofeedback treatment enhanced inspiratory volume. The speech amplifier increased loudness, prevented fatigue, and was implemented because of persisting inadequate loudness/vocal fatigue
Fifty baseline trials at maximal effort were performed: in this "no-feedback" condition, the patient never exceeded the 1 cm H_20 mark or 1-sec duration	Estimation of subglottal air pressure (cm H_20/sec)		With visual feedback, patient moved from generating 1 cm H_20/1 sec to 5cm H_20 for 2.5 sec.

(continues)

TABLE 1. *(continued)*

Reference	Type of Study	Primary Focus	Number of Subjects	Type of Dysarthria	Medical Diagnosis	Replicability	Psychometric Adequacy
Johnson & Pring (1990)	group with controls	"Less intensive" treatment targeting pitch & volume with visual feedback	12	not specified	PD	moderate	absent
Workinger & Netsell (1992)	case	Respiratory support and coordination exercises	1	not specified	TBI	moderate	absent
Cerny, Panzarella, & Stathopoulos (1997)*	group	Expiratory resistive breathing	10	not specified	hypotonia	high	present
Thompson-Ward, Murdoch, & Stokes (1997)	single case design	Tx 1: feedback on chest wall movement, Tx 2: feedback on chest wall movement & phonation	1	spastic	CVA	high	present
Murdoch, Pitt, Theodoros, & Ward (1999)	single case design	Traditional therapy vs. physiological biofeedback	1	mixed spastic-ataxic-flaccid	TBI	high	present

*The study by Cerny et al. (1997) on the use of expiratory resistive breathing in hypotonic children was most appropriately included in the biofeedback group. However, the nature of the treatment and the clinical population were generally inconsistent with the remainder of the studies in this group.

Evidence for Control	Measures of Impairment	Measures of Activity or Participation	Study Conclusions
Random assignment to a control (no treatment) group	F_0 range & modal pitches, loudest volume, volume range & mean volume in speech and reading; Frenchay Profile		Treated patients showed a significant improvement on volume & pitch measures, and the Frenchay Dysarthria Assessment; untreated group showed significant deterioration
Patient was 13 years post-TBI and had been discharged from therapies	Estimation of subglottal air pressure (cm $H_2$0/sec) and duration of vowel prolongation; number of syllables per breath; perceived ease of onset of phonation		After 12 months of treatment, patient was able to sustain /a/ for 15 sec, was able to produce six syllables/breath, and to use verbal communication functionally for first time since TBI.
Group improvement was statistically significant compared to (3) baseline measures	Expiratory muscle strength and endurance; subglottal pressure; sound pressure level		Compared to baseline: expiratory muscle strength increased 69% by 6 weeks; endurance did not change. Subglottal pressure increased 40%. Sound pressure level improved to 18%.
Used a multiple baseline design (experimental control). Prior to treatment, 6 baselines were conducted. Patient was 15 years post-CVA at treatment initiation	Tx 1: abdominal excursion and % abdominal contribution. Tx 2: offset latency and phonation times. Plus: Lung volume excursion, phonatory flows. Syllable/breath in reading.	Perceptual ratings of speech production (4 point scale)	Patient increased excursion of abdominal muscles for increased lung volumes & improved offset coordination and phonation times.
ABAC single subject experimental design. Baseline = 6 instrumental and 2 perceptual assessments over 2 days. Withdrawal = 6 instrumental and perceptual assessments over 10 weeks	Multiple spirometric, kinematic, aerodynamic, electroglottographic techniques, Frenchay Profile	Assessment of Intelligibility of Dysarthric Speech, and perceptual analysis of a reading sample	Real-time continuous visual biofeedback techniques effective & superior to the traditional therapy techniques (as measured instrumentally). Perceptual assessments after both treatment approaches revealed unremarkable progress.

TABLE 2. Table of evidence summarizing intervention studies utilizing devises.

Reference	Type of Study	Primary Focus	Number of Subjects	Type of Dysarthria	Medical Diagnosis	Replicability	Psychometric Adequacy
Hanson & Metter (1980)	case	Delayed auditory feedback	1	hypokinetic	PSP	low	present
Hanson & Metter (1983)	case series	Delayed auditory feedback	2	hypokinetic	PD	moderate	present
Rubow & Swift (1985)	single subject design	Portable biofeedback device	1	not specified	PD	moderate	present
Simpson, Till, & Goff (1988)	case	Voice amplifier (other biofeedback tx)	1	not specified	Basilar artery CVA	moderate	present
Adams & Lang (1992)	case series	Masking noise to increase voice intensity	10	not specified	PD	high	present
Cariski & Rosenbek (1999)	case series	Speech Enhancer with & without behavioral tx	2	hypokinetic	PD; multiple CVAs	moderate	absent

Evidence for Control	Measures of Impairment	Measures of Activity or Participation	Study Conclusions
Measurement of performance with and without DAF device	Vocal intensity during reading and counting	Rate & intelligibility during reading & counting. Family reported increased participation in conversations with DAF device.	When patient wore DAF device, improvements were demonstrated for speech rate, vocal intensity, and intelligibility. Positive effects maintained over 3 months of use.
Measurement of performance with and without DAF device	Voice intensity; fundamental frequency; phonation time for vowel /a/	Speaking rate during reading; speech intelligibility from connected speech samples.	Both patients showed marked reduction in speech rate, increase in vocal intensity, and improved speech intelligibility under DAF. They reportedly continued to wear the DAF devices outside of the clinic.
Comparison of Phase 1 of treatment (no feedback from device) with Phase 2 (feedback from device). Speech improvement while PD progressed.	Perceptual analysis (modified version of the 7-point, 38-dimension rating scale) & acoustic analysis of conversational & reading. Vocal intensity probes outside clinic.		The subject transferred a substantial portion of clinic improvement to the outside environment while wearing the feedback device and improved perceptually (on 8–9 out of 12 dimensions) and acoustically.
Patient was 33 MPO. Measurements taken with & without voice amplifier.	Speech intensity with and without voice amplifier	Reports of fatigue with speaking	Despite assistance from abdominal binder and biofeedback program, inadequate loudness & vocal fatigue persisted. Amplifier resulted in a 10-dB gain for a listener 3 ft away.
Comparison of baseline (no masking) to masking condition	Average speech intensity (dB SPL)	Speech intelligibility as measured by a perceptual scaling procedure (DME by four SLPs)	All patients showed a marked increase (statistically significant) in speech intensity with masking. Individual patients required different levels of masking. Effect on rate & intelligibility was inconsistent & nonsignificant.
Measurement with & without the Speech Enhancer; comparison to another type of amplification system. Failure of traditional tx and other amplifiers		Live transcription of orally read sentences for speech intelligibility.	Both patients' speech intelligibility scores increased across all three environmental test conditions when Speech Enhancer was utilized. Superior treatment results with speech tx in conjunction with using an amplification device.

TABLE 3. Table of evidence summarizing intervention studies using Lee Silverman Voice Treatment (LSVT).

Reference	Type of Study	Purpose of Study	Number of Subjects	Candidacy Summary	Type of Dysarthria	Medical Diagnosis	Replicability	Psychometric Adequacy
Countryman & Ramig (1993)	case	Document the effects of intensive tx. "Some improvement" after 6–7 months of biweekly traditional tx. A more intensive therapy program was felt to increase success.	1	Moderate speech and voice disorder from PD and bilateral thalamotomy	mixed hypokinetic-spastic	PD (with bilateral thalamotomy)	high	present
Countryman, Ramig, & Pawlas (1994)	case series	Documenting treatment effects in Parkinson Plus syndromes	3	Moderate to severe dysarthria from Parkinsonian Plus syndrome	not specified	Parkinsonian Plus syndrome	high	present
Ramig, Bonitati, Lemke, & Horii (1994)	group	First large group study of individuals with PD with follow-up data	40	PD with reduced loudness, imprecise articulation, etc.	not specified	PD	high	present
Dromey, Ramig, & Johnson (1995)	case	Documenting treatment effects in early stage PD	1	Soft/raspy voice from early stage PD	not specified	PD	high	present
Ramig, Countryman, Thompson, & Horii (1995)	group with controls	Comparison of 2 intensive txs with high effort, repeated drills designed to increase (1) respiratory support or (2) increase vocal fold adduction & respiratory support.	45	Mild-moderate speech/voice deficits from PD	not specified	PD	high	present

Evidence for Control	Measures of Impairment	Measures of Activity or Participation	Study Conclusions
Change in behavior demonstrated in patient with degenerative disease. Two pretreatment baseline measures taken.	Jitter; shimmer; amplitude modulation; frequency modulation; maximum duration of sustained vowel phonation; harmonics-to-noise ratio; intensity during sustained phonation, sentences, and paragraphs; fundamental frequency in sustained vowel phonation. Self-ratings of loudness & monotonicity. SLP's ratings of tremor and vocal fry.	Patient's self-ratings of slurring in speech. SLPs ratings of overall quality of speech/voice. Patient reports more confidence during social situations; increased participation in conversations.	Acoustic outcome measures were significantly improved immediately following treatment. Patient's and SLP's perceptual ratings also noted improvement pre- to posttreatment. However, 6 and 12 months posttreatment, acoustic measures indicated deterioration to or below baseline levels.
Improvement in context of degenerative disease.	Intensity, maximum duration & F_0 of sustained phonation. Intensity, mean F_0 and F_0 variability during reading and speaking. Perceptual rating of loudness, monotonicity, and slurring (imprecise articulation).	Perceptual rating of word and overall intelligibility	Data supported improvement in all pts. following 1 month of LSVT. By 6 months posttreatment, objective & perceptual data declined from immediately posttreatment levels. However, patients & families reported maintenance of overall functional communication skills.
Change in behavior demonstrated in patients with degenerative disease.	Sustained vowel duration; slow/forced vital capacities; max F_0 range; F_0 variability in reading. Perceptual rating of loudness.	Perceptual ratings of speech intelligibility & intonation. Depression inventories, Sickness Impact Profile, & Profile of Mood States. Patients & family members completed perceptual ratings of speech.	Statistically significant differences were measured pre- to posttreatment on maximum vowel duration, F_0 range, mean F_0 and F_0 variability (reading). Improvement in perceptual measures also found. Improvements maintained at 6 & 12 months whether or not subjects received additional treatment.
Baseline measures. Parallel changes observed in correlated variables.	Laryngeal (acoustic, aerodynamic & videostroboscopy), respiratory (lung volumes) & articulatory acoustic measures.		Increased vocal intensity; also changes in articulation noted that were not targeted in treatment.
Randomized tx groups. Improvement in context of degenerative disorder.	Intensity & duration of sustained phonation; intensity, F_0, F_0 variability, utterance & pause duration during reading & monologue. Family/patient self-ratings of loudness, monotonicity, & hoarseness.	Family/patient self-ratings of intelligibility & initiation of conversation. Beck Depression Inventory & Sickness Impact Profile.	Focusing on increased vocal fold adduction was more effective than respiration tx alone for improving vocal intensity & decreasing the impact of PD on communication.

(continues)

TABLE 3. *(continued)*

Reference	Type of Study	Purpose of Study	Number of Subjects	Candidacy Summary	Type of Dysarthria	Medical Diagnosis	Replicability	Psychometric Adequacy
Smith, Ramig, Dromey, Perez, & Samandari (1995)	group with controls	To study the interactive role of respiratory & laryngeal systems, & document laryngeal abnormalities.	22	Impaired speech from PD (ave. Stage III)	not specified	PD	high	present
Ramig & Dromey (1996)	group with controls	Comparison of 2 intensive txs on a variety of aerodynamic measures. Txs designed to increase (1) respiratory support or (2) increase vocal fold adduction & respiratory support.	17	Mild-moderate speech/voice deficits from PD	not specified	PD	high	present
Ramig, Countryman, O'Brien, Hoehn, & Thompson (1996)	group with controls	To document both short- and long-term effects of tx.	35	Dysarthria from early middle stage PD	not specified	PD	high	present
Countryman, Hicks, Ramig, & Smith (1997)	case	To improve the primary deficit (true vocal fold hypoadduction), reduce the need for secondary compensatory behavior (supraglottic hyperadduction), & result in improved loudness, intonation, and overall vocal quality.	1	Decreased vocal intensity of voice disorder from PD	not specified	PD	high	present

Evidence for Control	Measures of Impairment	Measures of Activity or Participation	Study Conclusions
Randomized treatment groups. Improvement in context of degenerative disease at chronic stage	Glottal phonatory configuration; glottal incompetence; supraglottic function; sound pressure level		Combined vocal & respiratory tx improved laryngeal adduction which correlated with increased vocal intensity. No differences in the respiratory only group.
Subset of patients randomized into treatment groups.	SPL for /a/, /pae/, reading, monologue; estimated subglottal pressure; maximum flow declination rate; open quotient of vocal folds; EGG pulse width adduction measure; forced vital capacity		Increases in SPL through improved vocal fold adduction & increase in subglottal pressure. SPL did not consistently increase pre- to posttreatment for subjects who received only respiratory training.
Random assignment to treatment groups; use of comparison group	Vocal intensity during sustained phonation, reading & conversation; F_0 during reading/conversation.	Beck Depression Inventory & Sickness Impact Profile.	Supports short- and long-term effectiveness of LSVT for improving vocal intensity in patients with PD. Only LSVT patients rated a significant reduction in the impact of their sickness on their communication skills after treatment.
Used a continuum of pre/post measures. Improvement in the context of chronic/degenerative condition	Sound pressure level; mean F_0 & its variability; maximum duration of sustained vowel phonation; electroglottographic & videolaryngostroboscopic data. Perceptual ratings of voice.	Perceptual ratings of speech during reading	LSVT increased vocal loudness, decreased supraglottic hyperadduction, & improved intonation & overall voice quality. Supraglottic hyperadduction may be secondary compensatory behavior & responded positively to adduction therapy (LSVT).

(continues)

TABLE 3. *(continued)*

Reference	Type of Study	Purpose of Study	Number of Subjects	Candidacy Summary	Type of Dysarthria	Medical Diagnosis	Replicability	Psychometric Adequacy
Theodoros, Thompson-Ward, Murdoch, Lethlean, & Silburn (1999)	case	LSVT used to improve voice/ speech deficits & document immediate & long-term effectiveness for both thalamotomy & pallidotomy.	1	Severe hypokinetic dysarthria from PD and thalamotomy/ pallidotomy surgery	hypokinetic	PD	high	absent
Ward, Theodoros, Murdoch, & Silburn (2000)	group with controls	Investigators wanted to determine if LSVT affects the physiological function of articulators, particularly the tongue. Additionally, differential patterns of long-term of LSVT had been found following neurosurgical management.	30	Mild to severe dysarthria from PD and/or surgical treatment of PD	not specified	PD with or without surgery	moderate	absent
Ramig, Sapir, Fox, & Countryman (2001)	group with controls	To compare treated group with untreated and normal age-matched controls	14	Moderate speech/ voice deficits from PD	not specified	PD	high	absent
Sapir, et al., (2001)	case series	To document tx effects for speakers with multiple sclerosis	2	Vocal weakness and fatigue from progressive MS	not specified	MS	high	present

Evidence for Control	Measures of Impairment	Measures of Activity or Participation	Study Conclusions
Baseline for perceptual, acoustic, & physiologic measures. Improvement in context of a degenerative condition	Acoustic measures of sound pressure level, duration of phonation, % voiced, jitter, shimmer, & fundamental frequency. Physiologic measures of subglottal pressure, laryngeal resistance, phonatory flow.	Perceptual measures of word/sentence intelligibility, number of intelligible words/minute, & communication efficiency. Number of syllables/breath & minute.	Results demonstrated marked improvement in intelligibility immediately post-LSVT (increases in vocal volume, phonatory stability, respiratory-phonatory control, & a decrease in rate of speech). At 6 months post-tx, however, initial gains in speech intelligibility & respiratory-phonatory control were not maintained.
Use of a clinical comparison group; improvement in context of a degenerative condition.	Sound pressure level during sustained phonation & reading; maximum tongue pressure, mean pressure over 10 repetitions of maximum pressure; number of repetitions with fast rate, maximum pressures produced in 10 seconds, & endurance.	Sentence intelligibility from the Assessment of Intelligibility of Dysarthric Speech	Both subject groups demonstrated significant improvements following LSVT across the measures of intelligibility & SPL in sustained phonation & reading. Assessment of tongue function, however, revealed that only the nonsurgical PD patients had increased capacity to generate maximal effort tongue pressures following intervention.
Randomization to groups; clinical (PD) & nonclinical comparison groups; improvement in the context of a degenerative condition.	Sound pressure level (SPL) during four speaking tasks		Significant increase in voice SPL from baseline to posttreatment & from baseline to the 6-month follow-up. Subjects with PD who did not receive treatment, as well as the non-brain-injured control subjects, did not demonstrate a significant increase in SPL.
Improvement in context of chronic/progressive condition. 3 baseline measures.	SPL during 4 speaking tasks; duration of sustained phonation. Perceptual ratings of loudness by SLP & naive raters.	Report of changes in functional communication & quality of life from speech-language summary reports.	Statistically significant improvement in SPL & duration of sustained phonation from pre- to post-tx & to the 6-month follow-up. Significant improvement in the perceptual rating of voice loudness after treatment. Both subjects indicated improved functional communication & quality of life.

(continues)

TABLE 3. *(continued)*

Reference	Type of Study	Purpose of Study	Number of Subjects	Candidacy Summary	Type of Dysarthria	Medical Diagnosis	Replicability	Psychometric Adequacy
Solomon, McKee, & Garcia-Barry (2001)	case	To document tx effects in TBI and add a 2nd tx phase to increase carryover	1	Moderately severe hypokinetic-spastic dysarthria from TBI	mixed hypokinetic-spastic	TBI	high	present
Ramig, Sapir, Country-man, et al., (2001)	group with controls	To assess effectiveness of a respiratory-phonatory treatment (LSVT) vs. a respiratory-only treatment, & measure the long-term (2 year) outcomes of treatment.	33	Mild to moderate dysarthria from PD	not specified	PD	high	present
Baum-gartner, Sapir, & Ramig (2001)	group with controls	To compare the effects of treatment emphasizing phonatory-respiratory effort with treatment emphasizing respiratory effort alone on perceived voice quality.	20	Moderate voice/speech problems associated with PD	not specified	PD	high	present

Evidence for Control	Measures of Impairment	Measures of Activity or Participation	Study Conclusions
Use of comparison treatments. Patient was 20 months post-TBI at tx initiation.	Chest wall kinematics, spirometry, laryngeal aerodynamic measures, & acoustic assessments. Perceptual ratings of loudness.	Speech intelligibility. Ratings of vocal press & intonation during reading. Patient's perception of decreased effort & acquaintances' comments about speech improvement.	After LSVT alone, improvements were generally minor & inconsistent, although sound pressure level & loudness increased notably. After additional 6 weeks of LSVT plus respiration and PT, gains documented for resting & speech breathing, vocal intensity, & sentence intelligibility. Several measures returned to baseline 3 months after treatment ceased, but some improvements in resting & speech breathing remained.
Randomization to groups; improvement in the context of a degenerative condition.	Sound pressure level, F_0, and variability in F_0 (semitone standard deviations) during sustained phonation, reading & conversational speech		LSVT significantly more effective than respiratory-only therapy in improving sound pressure level & pitch variability immediately posttreatment & maintaining those improvements at the 2-year follow-up.
Randomization to groups after stratification for stage, duration, severity of disease, & age. Listener's blinded to the participants & tx.	Perceptual ratings of breathiness & hoarseness by expert listeners based on tape-recorded readings of the Rainbow Passage.		Statistically significant pre- and posttreatment improvement in hoarseness & breathiness observed in LSVT group, but not in group that received respiratory therapy alone.

TABLE 4. Number of articles published during the past three decades.

Timeframe	Number of Unique Intervention Articles	Biofeedback	Use of Devises	Lee Silverman Voice Treatment	Miscellaneous
< 1980	1	1			
1980–1984	5	2	2		1
1985–1989	3	3	2		
1990–1994	6	2	1	3	
1995 thru 6/2001	20	3	1	13	3
Total	35	11	6	16	4

TABLE 5. Number of studies by type and intervention category.

Timeframe	Biofeedback	Use of Devices	Lee Silverman Voice Treatment	Miscellaneous	Total
Case/Case Series	5 (5)	5 (16)	7 (10)	1 (6)	18 (37)
Single Case Design	3 (3)	1 (1)			4 (4)
Group	1 (10)		1 (40)	1 (20)	3 (70)
Group with controls	2 (38)		8 (216)	2 (29)	12 (283)*
Total	11 (56)	6 (17)	16 (266)*	4 (55)	

**Note:* Number of subjects is overestimated because some subjects are represented in multiple studies. Total number of different subjects who underwent LSVT was approximately 90.

Numbers in parentheses represent number of subjects.

mat that will facilitate learning to regulate the physiological variable" (Rubow, 1984, p. 207). Impairments of the respiratory/phonatory systems are well suited to biofeedback because a number of important physiologic or voice parameters can be transduced and displayed for the speaker. For speakers with impaired respiratory support, estimates of subglottal air pressure have been used in a biofeedback paradigm (Daniel-Whitney, 1989; Netsell & Daniel, 1979; Workinger, 1995). Other respiratory/phonatory parameters suitable for biofeedback intervention include chest wall movement (Thompson-Ward, Murdoch, & Stokes, 1997), sound pressure levels of the voice (Cerny, Panzarella, & Stathopoulos, 1997), electroglottography (Murdoch, Pitt, Theodoros, & Ward, 1999), and duration of phonation (McNamara, 1983).

Rationale for Intervention and Candidacy Issues

Biofeedback treatment has been implemented for people with a wide variety of dysarthrias, including speakers having flaccid and mixed dysarthrias from traumatic brain injury (TBI) (n = 4 subjects), hypokinetic dysarthria from Parkinson disease (PD) (n = 39), and spastic, flaccid, and mixed dysarthria from stroke (n = 3). The rationale for specific intervention was typically based on the presence of a specific physiologic impairment that contributed to speech production difficulty, for example, poor respiratory support as indicated by inability to generate sufficient subglottal air pressure. Treatment was aimed at reducing the physiologic impairment. Case, case series, and single case design studies were common (7 of 11 studies) because physiologic intervention is usually designed to focus on the particular pattern of impairment for a given speaker. Case reports are most common in populations with marked symptom variability such as TBI and stroke, but group studies have been carried out in PD, spasmodic dysphonia (SD), and children with hypotonia.

Outcomes

Not surprisingly, outcomes of biofeedback treatment for physiologic impairment were usually measured in physiologic terms, for example, the level of subglottal air pressure generated during a certain speech production task, excursion of the abdominal and rib cage during speech, or sound pressure level during sustained phonation. Outcomes were reported at the level of the impairment in 10 of 11 studies. The outcomes in these studies were uniformly positive in that speakers were able to modify speech production in the desired way.

A review of Table 1 indicates that measures of activity and participation are less common, reported in 5 of the 11 studies. Outcomes at this level are not typically measured in a systematic way. Although anecdotal reports of improved communicative participation are encouraging, frequently the relationship between changes at the level of the impairment and changes in activity/participation is unclear. In one case, physiologic measures changed in the desired way, but perceptual assessment suggested unremarkable progress (Murdoch et al., 1999). In many other cases, measures of activity and participation were not systematically obtained, so a comparison between changes in impairment and in activity/participation could not be made.

The psychometric adequacy of the outcome measures was satisfactory across the majority of biofeedback studies. Procedures were rated as being either moderately or highly replicable in all cases. Most studies provided evidence for experimental control, that is, evidence that the intervention rather than other factors was responsible for the change in outcome measures. In the case of some individuals with TBI, treatment was initiated well beyond the period of spontaneous recovery. For example, speech treatment was initiated 13 years postinjury by Workinger and Netsell (1992) who suggested that intervention rather than spontaneous recovery or some other variable brought about the change. Baseline performance was reported in some studies (Cerny et al., 1997; Daniel-Whitney, 1989; Murdoch et al., 1999; Thompson-Ward et al., 1997). In other studies, experimental control was achieved through random assignment of subjects to treatment groups (Johnson & Pring, 1990; Scott & Caird, 1983). Thus, the reported results can be accepted with a fairly high level of confidence.

Devices

Several studies reported the use of devices as a means of supplementing speech production, specifically, DAF, voice amplification, and masking. In these studies, the primary purpose of the device was to improve the adequacy of speech; behavioral intervention was frequently a part of the management. Devices, such as mechanical ventilators, whose primary goal is to increase respiratory support, were not included even though improved speech production may have been a secondary outcome. Table 2 provides a detailed description of the studies of speakers using devices to improve respiratory/phonatory functioning. All of these studies were case reports, case series, or single subject designs.

Rationale for Intervention and Candidacy Issues

Candidacy for use of devices was often based on symptoms of inadequate loudness and a history of unsuccessful behavioral intervention. For the most part, the goal of intervention was to increase the loudness of speech for individuals with hypokinetic dysarthria associated with PD or, in a single case, progressive supranuclear palsy (PSP). One study reported the use of a speech amplifier by a speaker following a basilar artery stroke who was experiencing inadequate loudness and vocal fatigue.

Outcomes

Outcomes were frequently measured at the level of impairment, with variables including vocal intensity, fundamental frequency, and phonation time. These measures were often reported in conjunction with measures at the level of activity, including speaking rate and speech intelligibility. Measures of communicative participation were rare and involved family reports. One study (Rubow & Swift, 1985) probed vocal intensity outside the clinic setting. For the most part, outcomes were positive across levels of impairment and activity limitations, with changes in vocal intensity, speech intelligibility, or both.

The psychometric adequacy of the outcome measures was established in most of the studies. The methods were considered moderately replicable in the majority of studies. Because use of devices was the focus of intervention, most studies compared performance with and without the device as evidence of treatment effectiveness.

Lee Silverman Voice Treatment

Lee Silverman Voice Treatment (LSVT) is an intensive, high-effort speech treatment designed to rescale the magnitude of motor output of speakers with hypokinetic dysarthria associated with Parkinson disease. This treatment approach is highly replicable across studies with manuals and workshops available for clinician training and certification (Ramig, Pawlas, & Countryman, 1995). Goals are to increase phonatory effort, vocal fold adduction, and respiratory support. During 16 sessions (4 sessions per week for 4 weeks), speakers learn to produce loud speech. An emphasis is placed on recalibration of speech effort so that speakers appreciate their reduced level of effort and the need to increase it. Knowledge of results is provided to facilitate learning, and daily practice is required. The motivation for this treatment is to target the hypothesized underlying laryngeal pathology associated with the following symptoms: reduced loudness, intermittent hoarseness/harsh-raspy voice/vocal straining, abnormally low pitch, vocal fry, monotonicity, mildly impaired articulation, reduced respiratory support, and a mild vocal tremor. Separating LSVT from other categories of intervention allows for a description of the evolution of the evidence of treatment effectiveness over time. See Table 3 for details of these studies in chronological order of publication.

Rationale for Intervention and Candidacy Issues

The majority of patients described in this series of studies had a diagnosis of Parkinson disease and exhibited symptoms consistent with hypokinetic dysarthria, including phonatory hypoadduction and decreased vocal loudness. In the case of other diagnoses such as multiple sclerosis (MS) or TBI, symptoms reflected vocal weakness or fatigue and reduced vocal loudness. A profile of candidacy requirements emerges from a review of the literature. This candidacy profile is based on a constellation of symptoms (reduced loudness, poor respiratory support/effort), good stimulability such that performance improved with appropriate cues, and a high level of motivation to participate actively in an intensive program of practice. Patients with this profile can be found in several populations, with idiopathic Parkinson disease being the most common. Because the dysarthria types associated with MS or TBI are variable, some individuals with these diseases also fit the candidacy profile. Success of LSVT has been reported in a limited number of speakers with MS and TBI who fit the candidacy profile.

Outcomes

A review of Table 3 suggests an evolution of the evidence of treatment effectiveness over time. The earliest studies in 1993 and 1994 were case reports. These were followed by larger group studies such as Ramig, Bonitati, Lemke, and Horii (1994). Early group studies had methodological limitations, for example, reporting only pre- and posttreatment measures without control groups and providing minimal follow-up information. Subsequent group study added information that strengthened the overall body of evidence, for example, adding appropriate control groups, comparing LSVT with treatment designed to increase respiratory support only, and providing long-term (2 year) follow-up data. Subsequent case reports documented treatment effectiveness for speakers not represented in previous group reports, for example, a speaker in early stage PD with the symptoms of supraglottal hyperadduction (Countryman, Hicks, Ramig, & Smith, 1997), speakers with thalamotomy and pallidotomy (Theodoros, Thompson-Ward, Murdoch, Lethlean, & Silburn, 1999), and speakers with MS (Sapir et al., 2001). Another subsequent case report of an individual with TBI suggested that LSVT needed to be supplemented with a period of treatment focusing on respiration in order to be effective (Solomon, McKee, & Garcia-Barry, 2001).

Evidence of control in this series of studies can be found at a variety of levels. For case studies, improvement from baseline measures occurred in the context of progressive disorders. In LSVT group studies, randomization into various treatment groups, use of control groups, and documentation of improvement across the levels of impairment and activity/participation served to support the efficacy of the intervention.

The outcome of LSVT has been documented at multiple levels. Measures of the impairment have included a broad range of acoustic variables along with aerodynamic and kinematic measures. Family and self-reports of vocal features also documented the impact of intervention on the impairment in some studies. A variety of approaches have been used to measure activity/participation. These include ratings of overall quality of speech/voice, patient reports of confidence during social situations, and increased participation in conversations. In addition to these informal measures, some standardized psychosocial inventories also have been reported, for example, the Beck Depression Inventory (Beck, 1961) and the Sickness Impact Profile (Bergner, Bobbitt, Pollard, Martin, & Gilson, 1976). The effects of LSVT clearly have been documented with the widest range of outcome measures of any type of treatment reviewed here. Overall, the outcomes for LSVT can be interpreted with confidence and are for the most part positive.

Miscellaneous Studies

Group Therapy

Four studies were placed in the category of miscellaneous. Three of these studies involved therapy that was carried out in a group setting. These treatments were provided only to individuals with Parkinson disease (de Angelis et al., 1997; Robertson & Thomson, 1984; Sullivan, Brune, & Beukelman, 1996). Generally, group interventions targeted multiple aspects of speech production including respiratory control, voice projection, precise articulation, and in some cases speaking rate reduction. Interaction with other participants was common and took the form of discussions, interviewing, and role playing. Participants were encouraged to monitor relevant behaviors in themselves and others and to provide feedback on their observations. Interactions offered the opportunity to practice changes in speech production in typical communication activities. None of these group treatment studies were considered highly replicable. As a whole, the psychometric adequacy of these studies was judged to be low. Although all of these group studies reported success across all levels of disablement, including impairment and activity/participation, these results must be interpreted with caution. Thus, there is insufficient evidence to confirm the effectiveness of group treatment for respiratory/phonatory dysfunction in dysarthria.

Behavioral Management for Spasmodic Dysphonia (SD)

Murry and Woodson (1995) reported the result of a study of voice therapy after Botox treatment of SD. Voice therapy was implemented to address symptoms often reported by patients after Botox treatment, namely, extrinsic muscle hyperfunction and impaired regulation of breath flow during phonation. The investigators also wanted to determine if adjunctive voice therapy would result in the need for less frequent Botox injections. Their results suggested that subjects who received both Botox treatment and behavioral therapy demonstrated improved phonation as measured by increased airflow rate and acoustic measures of variability and perturbation. These changes persisted for longer periods compared to subjects who received Botox treatment alone. Results should be interpreted with caution because the number of subjects was small, and group assignment was not random. Extraneous factors, such as severity and motivation to improve, may have influenced the composition of the two groups. Neither expert opinion nor experimental studies support the effectiveness of behavioral treatment alone for SD (Dworkin & Meleca, 1997; Sapir, 1994). A more comprehensive description of medical interventions for SD is available elsewhere (Duffy et al., 2001).

CONCLUSIONS

This systematic review of the literature suggests that behavioral intervention for respiratory/phonatory dysfunction can be effective in modifying certain parameters in speakers with certain types of dysarthria and neurologic disease. It is important to recognize that this review did not address all of the treatments and techniques that have been used by clinicians to manage respiratory/phonatory dysfunction. Rather, it has focused on evidence that exists for treatments that investigators have developed, studied in a systematic way, and reported in the literature. Techniques and treatments for which there is only expert opinion about effectiveness, or lack thereof, are not included here. They are, however, addressed in the accompanying article (Spencer et al., 2003). It is hoped that the absence in this article of attention to common treatments or techniques will help motivate research to examine their efficacy. Finally, readers should recognize that treatments for which there is evidence of effectiveness do not necessarily represent the most appropriate or effective treatments that are available; they only represent the treatments for which evidence about treatment effects has been acquired. Similarly, evidence for the effectiveness of a treatment does not imply that it is an appropriate or necessary treatment for people with dysarthria in general or for individuals with respiratory/phonatory dysfunction from dysarthria. Decisions about the use of particular treatments are addressed elsewhere (Spencer et al., 2003).

The evidence reviewed supports the following conclusions.

1. *Biofeedback.* Biofeedback of physiologic activity can be effective in altering physiologic parameters associated with speech production (for example, subglottal air pressure, excursion of the abdomen and rib cage, sound pressure level). These effects have been demonstrated in single cases or small groups of people with flaccid, spastic, mixed, and

unspecified dysarthria types associated with stroke, Parkinson disease, TBI, and hypotonia. In general, the relationship between changes in specific physiologic variables and speech production or communicative participation has not been clearly established. The demonstrated effectiveness of biofeedback in altering physiologic variables, however, justifies a conclusion that it has the potential to impact speech production and communicative effectiveness and participation.

2. *Devices.* The use of devices, such as delayed auditory feedback, amplifiers, loudness feedback devices, and masking, have been shown to improve perceptual aspects of speech, such as loudness and intelligibility, in a relatively small number of speakers with hypokinetic or unspecified dysarthria types associated with stroke and Parkinson disease or related conditions. The evidence suggests that such devices can be effective for speakers with reduced loudness who have not experienced success with other forms of behavioral intervention. These conclusions are qualified by the small number of cases that have been reported and limited documentation of changes at the level of participation.
3. *The Lee Silverman Voice Treatment.* LSVT has been systematically studied in a relatively large number of speakers with Parkinson disease and hypokinetic dysarthria. In general, the data demonstrate that LSVT results in immediate posttreatment gains and that it is superior to treatment focusing on respiration alone. There is some evidence of long-term maintenance of LSVT effects, although the number of studies and subjects studied is limited. There also is some evidence to support effectiveness of LSVT in speakers with dysarthria with reduced loudness and hypofunction of respiratory/phonatory systems who do not have Parkinson disease (e.g., TBI, MS).
4. *Group Treatment.* Treatment in a group setting for speakers with Parkinson disease and respiratory/phonatory dysfunction has been reported in a small number of studies, with reports of success at the level of impairment and activity/participation. A review of the quality of the evidence, however, suggests that these treatments are not highly replicable (i.e., they are inadequately described) and that experimental control and other aspects of psychometric adequacy have been less than adequate. Therefore, at this time there is insufficient evidence to confirm the effectiveness of group treatment for respiratory/phonatory dysfunction in dysarthria.
5. *Behavioral treatment for spasmodic dysphonia.* No controlled studies of the effectiveness of voice therapy alone for treatment of neurologic spasmodic dysphonia were found in this review. Further, it appears that the general consensus from experts is that voice therapy alone for neurologic spasmodic dysphonia is not effective. A single study (Murry & Woodson, 1995) found that voice therapy following laryngeal Botox treatment was associated with longer lasting positive effects on certain voice parameters than did Botox treatment alone. This single study does not permit a conclusion that voice therapy in combination with Botox treatment is generally more effective than Botox treatment alone, but the finding justifies further investigation.

FUTURE DIRECTIONS

Researchers who focus on developing interventions should remain cognizant of levels of evidence for treatment efficacy. A report of a single case or a single case using single subject experimental design is not sufficient to establish a treatment's efficacy or effectiveness to a degree that supports its general acceptance and use. Establishing treatment efficacy is a difficult, painstaking process, and one that must be approached systematically and scientifically.

As part of the review process for this report, readers noted investigator comments about directions for future research. The readers and reviewers also made their own comments about research needs. These comments were distilled into some general directions for research as they pertain to treatments for respiratory/phonatory dysfunction for which there already is some evidence and treatments for which there only is testimonial support. Some areas of need that exist for all treatments for dysarthria are also considered.

These suggestions are not intended to be comprehensive, nor do they necessarily identify the most important treatment research needs. Nonetheless, they serve as examples of the kinds of studies necessary to advance the quality or level of evidence supporting conclusions that various treatments are or are not effective. They reflect the kinds of studies that may better inform us about the variables that predict success of various treatments for individual patients, and the studies that may help establish principles of treatment that may be universally relevant to the management of the dysarthrias.

1. *Biofeedback*. Most studies of biofeedback treatment have reported results only for single subjects. Even under rigorously controlled conditions, this is insufficient to permit generalization to a larger population. Well-conducted studies of larger numbers of subjects are also necessary to identify variables that predict biofeedback treatment outcomes. Comparison of biofeedback methods with nonbiofeedback treatments, including comparative cost-benefit analyses, are also necessary to refine clinical decision making about choice of available treatments. It is also essential that outcome data from biofeedback studies go beyond measurement of physiologic change to examine the relationship of such changes to changes in speech (e.g., perceptual attributes, intelligibility) and indices of social validity. Finally, if research on biofeedback remains promising, the development of simple, inexpensive systems for routine clinical use will become important.
2. *Devices*. The positive effects of delayed auditory feedback, amplifiers, loudness feedback devices, and masking, for the most part, have been demonstrated in studies of only one or two speakers. This evidence is insufficient to permit generalization of findings, so effects need to be demonstrated for larger numbers of speakers. Such studies will contribute a better understanding of variables that predict success with device use. Treatment studies also need to distinguish use of devices as prostheses from their use as treatment tools that may lead to generalization of effects without device use. It is essential that outcome data go beyond measurement of changes in loudness and rate to examine the relationship of such changes to changes in intelligibility and indices of social validity.
3. *Lee Silverman Voice Treatment*. Although evidence for positive effects of LSVT is strong relative to other treatments for respiratory/phonatory dysfunction, further study remains important. Long-term maintenance of effects, with or without ongoing treatment, requires additional documentation. Further study of treated subjects (and dropouts) to better define predictors of success and failure (e.g., severity of disease, severity of dysarthria, cognitive status, presence of dyskinesia, and etc.), and studies of "dose level" to define the minimal and optimal intensity and duration needed for benefit, are necessary. The degree to which LSVT may be beneficial for people with conditions other than Parkinson disease or hypokinetic dysarthria are also important to define further candidacy issues. Finally, treatment effects need to be replicated by different researchers as another component of the process necessary to determine if LSVT effects are replicable in the hands of many clinicians.
4. *Group therapy*. Studies conducted thus far generally have significant limitations regarding level of evidence. Well-controlled, replicable, and reliable studies of well-defined subjects are necessary to establish if group treatment of respiratory/phonatory dysfunction is beneficial, and ultimately if its effects are equivalent to or different from (better or worse) comparable individual treatment.
5. *Combined laryngeal Botox treatment and voice therapy for spasmodic dysphonia*. The results of the single study supporting this combination of treatments require replication under well-controlled conditions. Because the issue is one of treatment comparison (Botox treatment alone versus combined Botox and voice treatment), the clinical meaningfulness (i.e., size effects for clinically meaningful variables) of any differences and comparative cost/benefit analyses may eventually become appropriate.
6. *General issues related to the delivery of treatment*. Independent of specific treatments, research is needed to establish the optimal frequency, intensity, and duration of interventions for respiratory/phonatory dysfunction. As well, intervention research needs to address issues of timing. When is the optimal time to begin treatment? What are the criteria for terminating treatment? It is reasonable to assume that there are no universal answers to these questions and that, at a minimum, current health status, etiology, and predicted disease course are likely important variables to consider.

The relationship of the behavioral management of dysarthria to general principles of motor learning (e.g., knowledge of results, self learning, specificity of training, consistent versus variable practice, fatigue, and etc.) requires investigation. Two questions are fundamental: (a) What general principles of motor learning are applicable to the management of dysarthria? and (b) If applicable, do they apply equally across dysarthria types, various etiologies, and level of impairment (e.g., respiratory/phonatory dysfunction)? Answers to these questions may have important implications for refinement of existing treatments and may help guide the development of new ones.

Finally, methods for promoting generalization of treatment effects into natural communication settings need to be developed. By extension, investigations of treatment effects would benefit greatly from the development of a comprehensive set of outcome measures with demonstrated psychometric adequacy. Outcome measures at the level of impairment would presumably vary as a function of dysarthria type or level of dysfunction (e.g., respiratory/phonatory), whereas measures at the level of activity limitation/participation restriction might be more universally applied.

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