# Practice Guidelines for Dysarthria: Evidence for the Behavioral Management of the Respiratory/Phonatory System

## Technical Report Number 3

**Academy of Neurologic Communication Disorders and Sciences**

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## Table of Content

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## BACKGROUND

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. Practice guidelines serve to: insure equality of service and decrease variations in practice, improve the quality of services, identify the most cost-effective intervention, prevent unfounded practices, and stimulate needed research (Johnston, Maney, & Wilkerson, 1998). Practice guidelines are intended for use in making clinical decisions about the management of specific populations.

Development can be viewed as a process of translating evidence from both research literature and expert opinion into recommendations. The procedures for developing guidelines include the following:

- A panel of experts (the writing committee) is convened
- Assumptions are clarified and pertinent questions are identified
- An intensive literature search is conducted and relevant articles are retrieved
- Research is summarized and analyzed for validity
- Expert opinion is obtained
- Recommendations are drafted, reviewed, and revised
- Guidelines are distributed.

This portion of the dysarthria practice guidelines covers the topic of behavioral management of respiration and phonation. Other dysarthria modules include:

- Evidence for the Effectiveness of Management of Velopharyngeal Function (Technical Report available Nov. 2000; clinical focus article in the *Journal of Medical Speech-Language Pathology*, (2001) 9(4), 257-273)
- Medical Interventions for Spasmodic Dysphonia & Some Related Conditions:A Systematic Review (Technical Report available 11/01)
- Supplemented Speech (including alphabet supplementation, gestures and so on) (Technical Report due 6/02)
- Techniques for Enhancing Speech Intelligibility and Naturalness (Technical Report due 12/02)

## PROCEDURES

### The Question

The Writing Committee of Practice Guidelines for Dysarthria developed a list of clinical questions faced by speech-language pathologists caring for individuals with dysarthria. Specifically, the question being addressed in this document is the following: what behavioral techniques are appropriate for the management of respiratory/phonatory dysfunction in dysarthria?

### The Searches

We searched the following electronic databases: PsycINFO covering 1300 journals (1967 to June, 2001 ), MEDLINE covering 3900 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*, 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 these 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 2792 references. From this large search, references related to the respiratory and phonatory function were selected and those related to intervention were described, rated, and compiled in a Table of Evidence. 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, e.g. behavioral management of vocal nodules or functional dysphonia, and (4) did not involve behavioral intervention, e.g. electrical stimulation of the respiratory muscles or vestibular stimulation. Intervention studies that focus on prosodic aspects of speech production (e.g. enhancing stress patterning through pitch modulations) will be reviewed in the module entitled, “Enhancing Speech Intelligibility and Naturalness.” Review articles and chapters that survey intervention approaches are not included in the Table of Evidence but serve as supportive documentation for the Flowchart of Management Decisions.

## Rating 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). This scheme rates the strength of evidence for behavioral intervention studies by asking a series of questions such as the following:

How well are the subjects described?

We answered this question by noting the presence or absence of 18 subject descriptors similar to those described elsewhere (Strand & Yorkston, 1994). We also noted the candidacy requirements explicitly stated in the article along with type of dysarthria and medical diagnosis.

How well is the treatment described?

We answered this question by identifying the rationale for the intervention and rating the replicability of the intervention. An intervention technique was given the rating of high replicability 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 the criteria for replicability were rated as either low in this category if information was incomplete or moderate if general information about treatment procedures was provided.

What measures of control are imposed in the study?

We answered this question by noting the type of study and whether information was provided regarding the reliability and stability of the measures of the outcomes (e.g., inter- or intra-rater reliability, dispersion of judging scores, comparison of measures to gold standard, and so on). We also noted support for internal validity, for example, outcome measures obtained with and without a device, improved speech performance with intervention in the face of a progressive disorder, or presence of a comparison or control group.

Are the consequences of the intervention well described?

We answered this question by identifying the measures of outcomes at the levels of impairment, limitations in activity or participation. We also noted any reported risks or complications of the interventions.

## SUMMARY OF TABLE OF EVIDENCE

A total of 36 intervention studies were identified, obtained, and rated by at least two members of the Writing Committee. Characteristics of these studies are summarized in the accompanying Table of Evidence. Studies are listed in chronological order of publication. The following information has been abstracted from the Table of Evidence.

### Focus of Intervention

Articles describing and reporting the effectiveness of respiratory/phonatory management have appeared for over 35 years. The following table summarizes the number of articles published during the past three decades. Note that the majority of these studies have been published since 1990.

| **Timeframe** | **Number of Intervention Articles** |
|---|---|
| < 1980 | 2 |
| 1980s | 8 |
| 1990 thru 6/01 | 26 |
| Total | 36 |

Of the 36 intervention studies, 20 (56%) were cases or series of cases, while 16 (46%) reported groups comparisons. The case studies tended to be used in heterogeneous populations such as TBI, while group studies were more frequent in relatively homogeneous populations such as Parkinson disease. The studies reported on 425 individuals with dysarthria. Of the total number of subjects, 39 (9%) were reported as case studies or series of cases and 386 (91%) in group studies. It should be noted that the groups studies may overestimate the number of subjects with Parkinson disease since some of these subjects are represented in multiple studies. For example, studies reporting the impact of Lee Silverman Voice Treatment (LSVT) on laryngeal function are reported separately from those reporting acoustic findings. The total number of different subjects with Parkinson disease who underwent LSVT was 89 (Personal communication, Lorraine Ramig, Nov. 2000).

### Candidacy

A variety of subject characteristics were provided. Age, medical diagnosis, gender, and time post onset were reported most frequently (in over 85% of the articles). Other characteristics such as presence of cognitive problems or type of dysarthria were reported in less than half of the articles.

| Subject Characteristics | Percentage of Studies Reporting |
|---|---|
| Age | 100 |
| Medical diagnosis | 97 |
| Gender | 89 |
| Time post onset | 86 |
| Severity of dysarthria | 81 |
| Speech characteristics | 75 |
| Disease severity | 72 |
| Physiologic data | 72 |
| Medications | 61 |
| Neurologic examination data | 50 |
| Acoustic data | 47 |
| Treatment history | 44 |
| Cognition/language | 39 |
| Type of dysarthria | 36 |
| Hearing or vision | 28 |
| SES or education | 22 |
| Diadochokinesis | 14 |
| Sensation | 0 |

The most common medical diagnosis was Parkinson disease, reported in 61% of the articles. Other diagnoses included traumatic brain injury (TBI) reported in 14% of the articles and cerebrovascular accident (CVA) in 11% of the articles. For the most part, subjects were adults with acquired dysarthria rather than children.

| **Medical Diagnosis** | **Number of Articles Including that Diagnosis** | **Percentage of Articles** |
|---|---|---|
| Parkinson disease | 22 | 61 |
| Traumatic brain injury | 5 | 14 |
| Cerebrovascular accident | 4 | 11 |
| Progressive supranuclear palsy | 2 | 6 |
| Cerebral palsy | 1 | 3 |
| Multiple system atrophy | 1 | 3 |
| Shy-Drager syndrome | 1 | 3 |
| Multiple sclerosis | 1 | 3 |
| Adductor spasmodic dysphonia | 1 | 3 |
| Hypotonia | 1 | 3 |

In reviewing the description of candidacy and the rationale for intervention contained in the Table of Evidence, several general categories emerged. The most common explanation for selecting a particular intervention for a speaker with dysarthria was based on <u>physiologic features.</u> Because the respiratory subsystem provides the energy source and the phonatory system provides the sound source, both are critical to speech production. The contribution of the respiratory system to speech production in dysarthria has been the focus of intervention since the 1960s when Hardy (1964) studied the impact of posture on “lung function” in children with spastic quadriplegia and athetoid cerebral palsy. The respiratory system was frequently targeted for early intervention following TBI or stroke because other subsystems were dependent on improvement at this level. In speakers with flaccid dysarthria, the physiologic features that provided the grounds for intervention included markedly reduced vital capacity, inability to produce adequate subglottic air pressure, and inadequate respiratory support. These were often combined with poor laryngeal and velopharyngeal valving. In individuals with Parkinson disease, treatment was frequently designed to increase vocal fold adduction and respiratory support.

Selected <u>speech characteristics</u> also were used as a rationale for intervention. These typically included reduced ability to produce a voice or reduced speech loudness. In persons with Parkinson disease, speech characteristics also included accelerated speech rate, monopitch, and imprecise articulation.

Certain positive <u>prognostic indicators</u> were provided for intervention. For example, in speakers with flaccid dysarthria, improved phonation with pushing exercises was used as a rationale for a complete program to enhance respiratory drive. In persons with Parkinson disease, improved phonation with instructions to speak loudly was cited as a positive indicator of candidacy for treatment.

The history of previous interventions, including failure of other types of intervention, was cited as a rationale for some treatments. Use of devices, particularly delayed auditory feedback devices (DAF), portable intensity feedback devices, and speech amplifiers, was recommended because other types of treatment were unsuccessful.

Evidence from the literature matching type of treatment with dysarthric speakers deemed to be good candidates also was used as a rationale for treatment. Some interventions were chosen because they "had been previously proven effective" with similar patients. Other interventions were designed to address specific problems, for example, the problem of generalization of intervention for persons with Parkinson disease. The most highly refined programs such as LSVT described how the program of intervention followed the principles of motor learning (e.g. integration of knowledge of results into therapy) that were adopted from research literature outside the field of speech pathology.

## Description of Intervention

Adequacy of the description of the interventions is critical. Over half (58%) of the interventions for respiratory/phonatory dysfunction received a high rating for replicability. Another 39% of the articles were judged to provide general information about how to carry out the intervention (rating of moderate). In the remaining 3% of the studies, the description of the intervention was judged to be incomplete (rating of low).

The column entitled "Evidence for Control" lists information supporting the assertion that the treatment of interest was responsible for the change in behavior/outcome measures. Group comparisons were frequently used as evidence for control. In some cases, particularly with work of Ramig and her colleagues, individuals were randomly assigned to various intervention groups. At times, group studies involved a comparison with an untreated group (Robertson & Thomson, 1984). At other times, group studies involved a comparison between two types of intervention, for example, a comparison of various speech amplification devices (Cariski & Rosenbek, 1999) or a comparison of intervention focusing on increasing respiratory support with one focusing on increasing vocal fold adduction and respiratory support (Ramig, Countryman, O'Brien, Hoehn, & Thompson, 1996; Ramig, Countryman, Thompson, & Horii, 1995; Ramig & Dromey, 1996). Several of the studies of respiratory/phonatory intervention in Parkinson disease also reported long-term follow up information that suggested stability of outcomes in the face of a degenerative disease. When devices such as amplifiers or DAF units were involved, a comparison of speech performance with and without the device was used as evidence of intervention effectiveness.

A variety of single-case design research methods were also used as evidence of control. These methods included a comparison of the various phases of intervention (Rubow & Swift, 1985), use of extended baselines to document stability of performance (Daniel-Whitney, 1989), multiple baseline designs (Thompson-Ward, Murdoch, & Stokes, 1997), and treatment withdrawal designs (Murdoch, Pitt, Theodoros, & Ward, 1999). Time post onset also served as evidence that intervention was effective in some studies. For example, some cases with TBI or stroke were well beyond the point of spontaneous recovery when treatment was undertaken. This suggests that intervention rather than natural course of recovery was more likely to be responsible for the improved performance. In another example, speakers with Parkinson disease showed improved speech performance in the face of a degenerative condition thus lending some support to the effectiveness of treatment.

Few risks or complications of speech intervention for respiratory/phonatory disorders were noted. In one study of speech intervention for individuals with Parkinson disease, the authors reported that several subjects experienced fatigue associated with the intensive treatment program (Robertson & Thomson, 1984). In another study, a speaker with Parkinson disease reported fatigue and increased hoarseness (Rubow & Swift, 1985). In the Ramig and Dromey (1996) study comparing two types of intervention, the respiratory only intervention was felt to be counterproductive in that glottal incompetence was increased rather than decrease in some cases. Side effects not related to behavioral intervention also were occasionally reported. In one case, dry mouth was associated with drug intervention (Daniel-Whitney, 1989). In another case, discomfort related to the rigid telescope used to measure outcomes was reported (Smith, Ramig, Dromey, Perez, & Samandari, 1995).

## Types of Studies

The following table summarizes the type of study for four categories of treatment focus. Various forms of biofeedback (i.e., intraoral air pressure, chest wall movements, volume, pitch) were utilized as a primary form of treatment in 10 of the 36 studies. Several studies reported the use of devices, specifically, DAF, voice amplifiers, and a masking device. Three studies examined the efficacy of group treatment for respiratory/phonatory impairment. Finally, 16 studies of the Lee Silverman Voice Treatment were conducted. A review of the following table suggests that treatment studies involving devices were for the most part case studies or series of cases. On the other hand, a substantial number of group studies with control subjects were reported for LSVT. As is typical other areas of intervention, early studies of LSVT were case reports and later studies involved larger groups with various types of control.

| Number of articles in each categories of treatment focus and study type. Note that some studies are included in more than one study type. | | | | |
|---|---|---|---|---|
| | Biofeedback | Devices | Group Treatment | LSVT |
| Case/Case Series | 4 | 5 | 1 | 7 |
| Single Case Design | 2 | 1 | | |
| Group | 1 | | 1 | 1 |
| Group with Control Subjects | 3 | | 1 | 8 |

## Outcomes

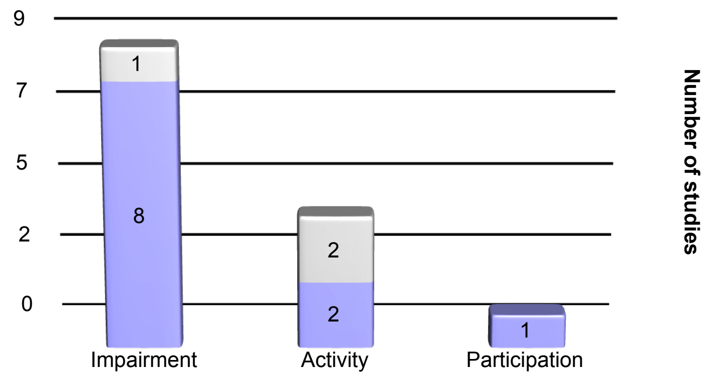
A variety of outcome measures were obtained. These were categorized using terminology from the International Classification of Function, Disability and Health (International Classification of Function, Disability and Health, 2001).

> Impairment: A loss or abnormality of body structure or of a physiological or psychological function (example from dysarthria – inability to generate subglottal air pressure for speech).
>
> Activity Limitations: Activity is the nature and extent of functioning at the level of the person. Activities may be limited in nature, duration and quality (example from dysarthria – speech is reduced in intelligibility or naturalness).
>
> Participation Restriction: Participation is the nature and extent of a person's involvement in life situations in relation to impairments, activities, health conditions, and contextual factors. Participation may be restricted in nature, duration, and quality (example from dysarthria: report of restrictions in the use of speech in natural communication contexts, such as public speaking).

The psychometric adequacy of measurement was assessed by indicating whether information was provided regarding reliability and stability of the outcome measures. For example, inter- or intra-rater reliability, dispersion of judges' scores, and comparison of measures to a gold standard were all considered evidence of psychometric adequacy. The majority of the studies (72%) contained evidence of psychometric adequacy.

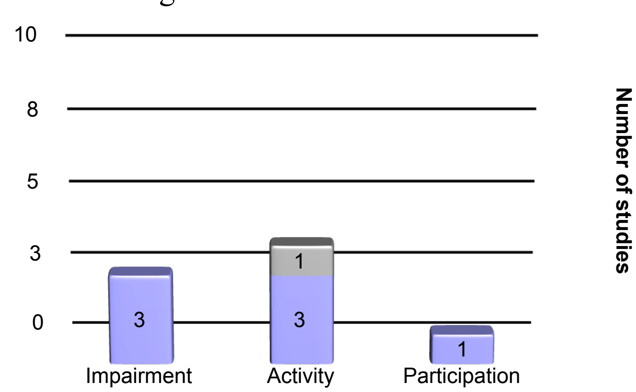
Treatment strategies implemented in two or more studies were grouped together to (1) determine the general level of success reported for various therapies in the extant literature, (2) ascertain the patterns that exist across types of outcome measures, and (3) consider the patient populations studied for each category of treatment. Results are reported in the context of the level of methodological control imposed in the studies (i.e., the psychometric adequacy of the outcome measures and the support for internal validity).

Figure 1. Positive (blue) and negative (gray) outcomes for **biofeedback studies** (n=10)




The psychometric adequacy of the outcome measures was satisfactory across the majority of **biofeedback** studies (7/10). Sufficient evidence of internal validity also was provided for 9/10 of these studies. Thus, the reported results can be interpreted with a fairly high level of confidence. As shown in Figure 1, positive treatment results were reported for most studies measuring outcomes at the level of impairment. However, half of the treatment outcomes were found to be unsuccessful when measured at the level of activity limitations. Outcomes of participation were rarely measured. The biofeedback treatments were implemented with speakers having flaccid and mixed dysarthrias from TBI (n=4), hypokinetic dysarthria from PD (n=39), and spastic, flaccid and mixed dysarthria from CVA (n=3). Although biofeedback was shown to be ineffective at times, the majority of studies reported positive effects, predominantly at the level of the impairment. The success of biofeedback at the activity and participation level remains largely unsubstantiated.

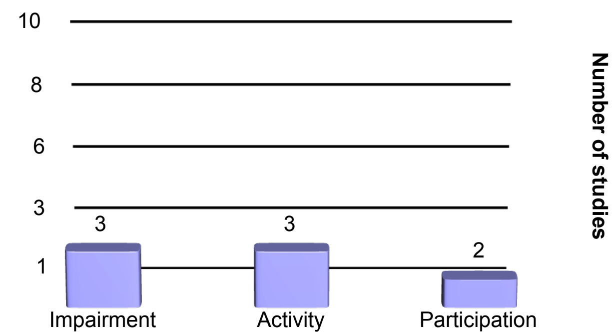
Figure 2. Positive (blue) and negative (gray) outcomes for **studies using devices** (n=4) according to level of disablement




The psychometric adequacy of the outcome measures was established in the majority of studies involving **devices** (3/4). Internal validity was demonstrated for all four studies. The reported results can therefore be interpreted with confidence. Figure 2 illustrates the generally positive findings for the use of devices in the treatment respiratory/ phonatory functioning both the impairment and activity level. Once again, outcomes measures were rarely considered at the level of participation. Studies of devices focused on persons with Progressive Supranuclear Palsy (n=1) and PD (n=14), so type of dysarthria was predominantly hypokinetic and the course of the disorder was progressive. Although successful use of devices was generally reported in all four studies across types of outcome measures, the small number of studies limits statements of overall benefit.

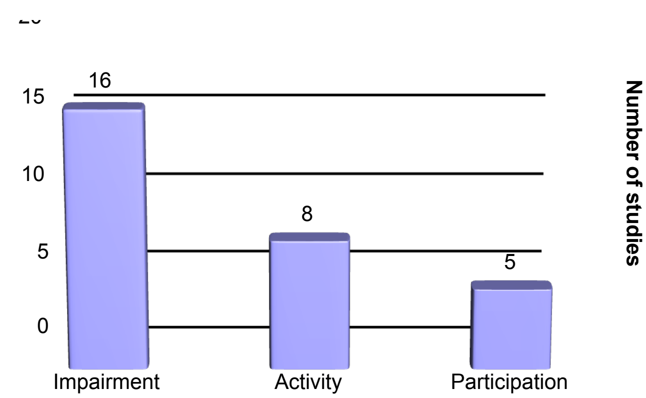
As a whole, the psychometric adequacy and internal validity of these studies involving group treatment were lacking, suggesting a more cautious interpretation of the treatment results. Nonetheless, all treatments reported success across all levels of disablement. Speakers with Parkinson disease (n=38) were the sole focus of the group treatment studies.

Figure 3. Positive (blue) and negative (gray) outcomes of **group treatment** (n=3) according to level of disablement.




Internal validity was satisfactory across all **LSVT** studies and the outcome measures were psychometrically sound in the majority (13/16) of studies. Positive outcomes for LSVT treatment, which can be interpreted with confidence, were reported for all studies, as illustrated in Figure 4. Each study of LSVT measured performance at the impairment level, while half measured performance at the activity level. The emergence of outcome measurement at the participation level is noted.

Figure 4. Positive (blue) and negative (gray) outcomes of LSVT (n=16) according to level of disablement




The patient population for which LSVT was implemented included persons with PD (with and without thalamotomy or palidotomy surgery; n=90+), Parkinson Plus Syndromes (n=3), MS (n=2), and TBI (n=1). Thus, LSVT has consistently reported positive treatment results, particularly at the impairment level, but often at the level of activity limitation and participation restriction as well.

## Conclusions and Future Research

The behavioral management of respiratory/phonatory impairment has support from the research literature, particularly in the areas of biofeedback and intensive phonatory treatment (LSVT). The vast majority of research participants treated for respiratory/ /phonatory impairment had dysarthria from Parkinson disease, but speakers with flaccid, spastic and mixed-ataxic dysathrias were often considered. Although many interventions were shown to be effective in particular speakers with dysarthria, a number of issues warrant further research, as summarized below.

| **Considerations of future research based on a review of the respiratory/phonatory treatment literature** |
|---|
| |
| **Optimizing learning and timing of intervention** |
| • How to incorporate the principles of motor learning into intervention for dysarthria, in terms of optimal frequency, intensity, and duration of intervention |
| • Techniques to improve generalization |
| • Timing of intervention including when to begin and when to stop |
| • When it is appropriate to use non-speech activities and when it is more beneficial to use speech production activities |
| • The role of maintenance treatment in Parkinson disease |
| • Studies comparing group versus individual treatment |
| |
| **Outcomes** |
| • The use of a more comprehensive set of outcome measures (including measures of communicative participation) |
| • Better descriptions of the psychometric adequacy of the outcome measures |
| • Better studies of outcome measures with an eye on the question, what amount of difference is an important difference? |
| • The effect of testing intelligibility in adverse conditions such as in noise |
| • Qualitative investigations of the impact of intervention |
| • The need to expand outcome measures to include studies of the secondary impact of respiratory/phonatory training on other aspects of speech |
| |
| **Improving the rigor of evidence** |
| • In addition to case studies, group studies, particularly those with a comparison group, are needed |
| • Long-term follow-up is necessary to determine maintenance of outcomes |
| • More single case design studies are warranted given the heterogeneity of the dysarthric population |

| |
|---|
| |
| **Under-represented populations** |
| • Studies of other populations with known respiratory impairment such as Huntington disease |
| • Studies of the impact of treatment on children with dysarthria |
| |
| **Devices** |
| • Development of simple biofeedback systems |
| • Clarification of the underlying mechanism for the effectiveness of DAF to lead to a better description of candidacy criteria |
| • The role of devices to promote generalization |
| • Better descriptions of “good” and “poorer” candidates for devices such as masking or DAF |
| **Other factors** |
| • Studies of the effects of combinations of treatment such as respiratory/phonatory exercises with velopharyngeal management in populations such as TBI |
| • Studies of fatigue and its relationship to speech production and respiratory compromise. This would include outcome measures such as self-reports of effort and fatigue. |
| • The effects of posture across groups of individuals with dysarthria |
| • Pharmacological treatment of factors such as myocolonus that interfere with respiratory/phonatory control |

## FLOW CHART OF DECISIONS IN RESPIRATORY/PHONATORY MANAGEMENT

Respiratory/phonatory impairment is a common manifestation of dysarthria and can have a major impact on the adequacy of speech production. Treatment of the respiratory and phonatory subsystems is often given priority because improvements at this level generate improvements in other aspects of speech as well (Hayden & Square, 1994; Netsell & Daniel, 1979; Ramig, 1992; Rosenbek & LaPointe, 1985; Yorkston, Beukelman, Strand, & Bell, 1999). A number of techniques reviewed in the previous section have proven effective for respiratory/phonatory dysfunction. In the context of everyday clinical decision-making, it may be helpful to view this research as it pertains to the nature of the deficits experienced by persons with respiratory/phonatory impairment. If functioning is reduced at the respiratory/phonatory level, it is likely to stem from one (or more) of three main areas: (1) decreased respiratory support, (2) decreased respiratory/phonatory coordination and control, or (3) reduced phonatory function. Despite the natural coupling of the respiratory and phonatory systems, this theoretical separation encourages the clinician to methodically approach treatment of the compromised areas. To this end, the research just reviewed, as well as expert opinion from review articles, book chapters, and so on, will be discussed in the next section in terms of the support they lend to management strategies for the three main areas of respiratory/phonatory impairment.

We focus now on strategies for the behavioral management of respiratory/phonatory problems in dysarthria. This discussion is based on the evidence from the literature just reviewed and on expert opinion. Figure 5 illustrates a clinical decision-making flowchart; the circled letters on the chart refer the reader to the corresponding part of the text. Note that the figure is organized into 2 sections: Assessment of Respiratory Function (A and B) and Management of Reduced Function (C – Q).

### Assessment of Respiratory/Phonatory Function (Figure 5A)

Understanding normal respiratory and phonatory function is a requisite foundation for the management of individuals with dysarthria. A detailed review of the anatomical and physiological underpinnings of the speaking and breathing apparatus is beyond the scope of this report. However, a brief overview might serve as a fitting transition to the evaluation strategies discussed below. For a complete overview of normal respiration for speech, readers are referred to sources such as Hixon (1987), Warren (1996), or Weismer (1985).

The respiratory system is comprised, essentially, of the bones, cartilage, tissues and muscles that form our lungs, airways, rib cage, abdomen, and diaphragm. It provides the basic energy source for all speech and voice production, regulating such important parameters as loudness, pitch, linguistic stress and the division of speech into units (Thompson-Ward & Murdoch, 1998). It is the balanced activity of the inspiratory and expiratory muscles of the respiratory system that provides the constant subglottal pressure needed for phonation (Kent, 1997b). Generally, the respiratory goal of a speaker is to generate steady subglottal air pressure during an utterance with rapid and slight variations for stress patterning. At any given time, the subglottal air pressure level during speech is a reflection of the driving forces of the respiratory system and the resistance to airflow imposed by the laryngeal and supralaryngeal structures (Yorkston et al., 1999).

The larynx is composed of cartilage, muscles and tissue. The vocal folds of the larynx serve to valve the air from the respiratory system for the production of sound. Normal phonation requires precise motor control to regulate the dimensions of voicing and pitch. Adequate voicing of speech sounds requires complete adduction at the midline of the vocal folds and precisely timed glottal opening and closing; the vocal folds must adduct at the exact moment of onset for voiced consonants and vowels, and abduct for voiceless consonants (Aronson, 1985). Pitch variation is produced by changes in the longitudinal tension of the vocal folds. Rapid pitch adjustments rely on the ability of the extrinsic laryngeal muscles to swiftly elevate and depress the larynx. Thus, normal speech production depends on coordinated interaction within and between the respiratory and laryngeal systems. The airflow generated from these systems is subsequently modified and shaped by the articulatory and velopharyngeal mechanisms. When any of these subsystems are affected by a neuromotor disturbance, dysarthria is a likely consequence.

## History and Referral Information

Assessment of respiratory/phonatory function typically begins by gathering information about the history of the problem, such as (1) onset and medical history, (2) nature, duration and course of dysfunction, (3) report of previous treatment, (4) level of patient's concern about the impairment, social limitations, and so on, and (5) patient's motivation relative to treatment. Specific attention should be paid to the patient's presenting complaints as they may provide the initial evidence of respiratory or phonatory involvement. Examples of complaints that may be particularly revealing are:

- Fatigue during speech (Duffy, 1995; Yorkston et al., 1999)
- Shortness of breath at rest, during exertion, or during speech (Duffy, 1995; Yorkston et al., 1999)
- Ability to say only a few words per breath (Yorkston et al., 1999)
- Inability to increase loudness or shout (Yorkston et al., 1999)
- A weakened cough (Smeltzer et al., 1992)
- Speaking against resistance or effortful to speak (Duffy, 1995)

## Motor Speech Examination

Assessment of speech characteristics also can provide a window into the nature and existence of respiratory and/or phonatory subsystem involvement. As outlined by Yorkston et al. (1999), the adequacy of respiratory functioning for speech can be determined, in part, by the perceptual evaluation of *loudness* and *breath patterning*. Inadequate loudness and improper control of loudness, as well as abnormal patterning of inhalation and exhalation during speech, may serve as indicators of impaired respiratory support/coordination. The following are specific observations to make regarding loudness and breath patterning while the patient is speaking (Yorkston et al., 1999):

Loudness

- Overall loudness level that is too low or too high
- Inconsistent loudness level
- Sudden, uncontrolled alterations in loudness
- Loudness diminishes over the course of a single breath group or over the course of extended speech
- The patient is unable to increase loudness
- The patient is unable to speak quietly
- The patient is unable to emphasize words in a sentence by increasing loudness.

Breath Patterning

- The patient does not demonstrate the normal pattern of quick inhalation followed by prolonged exhalation
- The patient does not inhale to appropriate lung volume levels (but see Chenery, 1998)
- The patient initiates speaking at atypical points in the respiratory cycle
- All pauses contain an inhalation
- Speech is interrupted by sudden, forced inspiratory/expiratory sighs
- Exaggerated respiratory maneuvers (e.g., excessive elevation of the shoulders) are apparent during speech
- The patient runs out of air before inhaling
- The patient produces few words/syllables on one breath
- Breaths occur at syntactically inappropriate locations in the utterance.

Adequacy of phonatory functioning can initially be described by a *voice quality* rating. There is not a generally accepted method of evaluating speech quality; however, for most purposes, a simple voice rating scale for dimensions such as hoarseness, breathiness, roughness, and pitch level will suffice (Kent, Kent, Duffy, & Wesmer, 1998). Specific voice characteristics such as phonatory instability, tremor, ability to vary pitch, excessive fluctuations of pitch, inhalatory stridor, and wet phonation should be considered for a more thorough depiction of the phonatory abnormalities associated with the dysarthrias.

## Physical Examination

A physical examination of the structure and function of the speech mechanism should be conducted, particularly if there are concerns of respiratory involvement. As recommended by Hoit (1995), the body position of the patient during evaluation (and treatment) should be considered, and should reflect the typical, day-to-day context for breathing activities and positioning. A number of observations can be made of the patient during quiet breathing (drawn from Duffy, 1995 unless otherwise indicated), such as:

- Abnormal posture
- Rapid, shallow or labored breathing
- Limited range of abdominal and thoracic movements
- Shoulder movements, neck extension, neck retraction, or flaring of the nares on inhalation
- Irregular breathing rate; abrupt movements which alter normal cyclical breathing
- Paradoxical movements of the thorax and abdomen, i.e., the thorax expands while the abdomen retracts, or vice versa [Yorkston, 1995 #4437]
- Audible breathy inspiration, inhalatory stridor, or an audible grunt at the end of expiration (Chenery, 1998)

Observation of these symptoms may provide insight into the presence of respiratory/ phonatory impairment, and whether the dysfunction stems from weakness, incoordination, involuntary movements, and/or maladaptive strategies.

For an exceptionally comprehensive physical examination by speech-language pathologists of persons suspected of having a speech breathing disorder, the reader is referred to protocols developed by Hixon and Hoit (1998, 1999, 2000). The degree of abnormality of the diaphragm (1998), abdominal wall (1999), and rib cage wall (2000) can be thoroughly assessed using a five-point scale (worksheets included) while the patient performs exercises designed to elicit specific clinical observations. Additionally, Redstone (1991) provides guidelines on assessing respiration in children with multiple disabilities and subsequent abnormal muscle tone.

A thorough examination of the respiratory/phonatory system is appropriate when abnormalities are noted during the assessment of speech characteristics (e.g., loudness levels, breath patterning, and vocal quality) or observations of quiet breathing. A description of this assessment will be organization into three major areas of dysfunction: (1) decreased respiratory support, (2) reduced respiratory/phonatory coordination and control, and (3) compromised laryngeal functioning. Each of these areas will be discussed in terms of the potential evaluative strategies one might employ for a more comprehensive assessment. Strategies will be based on “clinical screening” methods and instrumental techniques, although the lack of widespread clinical use of instrumental measures is recognized (Coelho, Gracco, Fourakis, et al., 1994).

<u>Decreased respiratory support</u>

Decreased respiratory support may occur in varying degrees of severity in individuals with dysarthria, but would be especially prominent in patients with lower motor neuron involvement (i.e., flaccid dysarthria). Confirming the presence and extent of reduced respiratory support can be accomplished in several ways including screening methods available in most clinical settings, and more elaborate instrumental measures.

Clinical Screening

Screening methods provide only a general gauge of respiratory functioning, but may be the only available clinical testing methods in some settings.

- A simple **water glass manometer**, originally discussed by Hixon, Hawley, and Wilson (1982), can provide a gross measure of the minimum and maximum pressure-generating capabilities for speech production. The conventional '5 for 5' rule suggests that an individual must be able to sustain a pressure of 5cm $H_2O$ for 5 seconds to have sufficient respiratory support for speech (Netsell & Hixon, 1978; Rosenbek, 1984). Netsell (1998) suggests using the criterion of 10cm $H_2O$ pressure for 10 seconds for patients with reduced range/speed of articulators, hypo- or hyper-adducted vocal folds, or shallow breathing and long inspiratory pauses.
- A **hand-held respirometer** is an economical device for gathering data on vital capacity (Beckett, 1971). Measures from the respirometer can be converted to a proportion of predicted normal vital capacity using formulas that incorporate the patient's age and height (Kent, 1994). Gross indicators of impairment, particularly with respect to persons with amyotrophic lateral sclerosis, also can be found in Hillel and Miller (1989) and Yorkston, Strand and Hume (1998).
- Contrasting the **sharpness of the patient's cough** with the glottal coup may help separate respiratory from laryngeal contributions to reduced respiratory drive. A weak cough with limited abdominal and thoracic excursion may reflect respiratory weakness (Duffy, 1995); whereas a weak glottal coup implies laryngeal involvement. This is a very gross indicator of respiratory support, however, as the production of a strong, voluntary cough requires considerable respiratory support and vocal fold adduction (Yorkston et al., 1999).
- **Sustained phonation time** is also used as a very general estimate of respiratory/phonatory capacity. There are numerous caveats surrounding the use of maximum sustained phonation as a reflection of respiratory functioning, including: (1) it is confounded by the interactions such as level of effort and loudness (Kent, 1997a; Robin, Solomon, Moon, & Folkins, 1997; Yorkston et al., 1999); (2) it more accurately reflects maximum respiratory capacity rather than breath support for speech (Yorkston et al., 1999); and (3) age effects can be profound (Kent, 1997a).
- **Sustained phonation with changes in loudness** may also be implemented to estimate respiratory drive. Inherent to this method are the same caveats found with standard sustained phonation exercises. However, if the patient is capable of abruptly increasing loudness, this does provide a gross indication of the ability to volitionally raise subglottal air pressure.

Instrumental Measures

To obtain more precise information regarding the patient's respiratory drive and capacity, instrumental measures should be employed. The following are methods for assessing the four respiratory parameters of (1) subglottal air pressure, (2) lung volume, (3) air flow, and (4) chest-wall shape in adults and children with suspected respiratory dysfunction (Robin et al., 1997; Solomon & Charron, 1998). Also, see Horton, Murdoch, Theodoros, and Thompson (1997) and Murdoch, Johnson, and Theodoros (1997) for specific protocols for obtaining physiologic measures of speech breathing.

- Subglottal air pressure
    - Placing one end of a small tube in the mouth with the other end connected to a pressure transducer
    - U-tube manometer with a leak to simulate laryngeal resistance
- Lung volume
    - Spirometer
    - Pneumotachograph
    - Measuring motions of the chest wall and calibrating this to known volume measures
- Airflow
    - Spirometer
    - Pneumotachometer
    - Chest-wall kinematics
- Chest-wall shape
    - Respiratory inductive plethysmography or magnetometry (kinematics)

As discussed by Thompson-Ward and Murdoch (1998) the speech-language pathologist (SLP) may obtain a number of valuable respiratory/airflow measures (e.g., vital capacity, forced expiratory volume, functional residual capacity, inspiratory capacity, and expiratory/inspiratory reserve volumes) and subsequently compare them to predicted values based on the patient's age, height and sex. Additionally, kinematic assessment allows the SLP to infer the airflow volume changes from the rib cage and abdominal displacements.

Reduced Respiratory/Phonatory Coordination

Reduced respiratory/phonatory coordination may be evidenced most often in persons with ataxic and hyperkinetic dysarthrias or in children with cerebral palsy.

Clinical Screening

Screening methods for determining incoordination would be based largely on the physical examination and breath-patterning observations during connected speech (discussed earlier), specifically:

- Shoulder movements, neck extension, neck retraction, or flaring of the nares on inhalation
- Irregular breathing rate; abrupt movements which alter normal cyclical breathing
- Paradoxical movements of the thorax and abdomen, i.e., the thorax expands while the abdomen retracts, or vice versa (Yorkston et al., 1999)
- The patient does not demonstrate the normal pattern of quick inhalation followed by prolonged exhalation
- The patient initiates speaking at atypical points in the respiratory cycle
- Speech is interrupted by sudden, forced inspiratory/expiratory sighs
- Exaggerated respiratory maneuvers (e.g., excessive elevation of the shoulders) are apparent during speech
- The patient runs out of air before inhaling
- Breaths occur at syntactically inappropriate locations in the utterance

Additionally, SLPs can feel for gross changes in chest wall shape by placing one hand over the diaphragm and the other on the rib cage (Robin et al., 1997; Yorkston et al., 1999). As noted by Yorkston and colleagues, however, this method is extremely informal and cannot yield precise or objective measures of shape, timing or respiratory volume.

Instrumental Measures

Instrumental assessment of respiratory/phonatory coordination often involves kinematic methods. Kinematic measures are based frequently on magnetometer systems or respiratory inductive plethesmography ("Respitrace") and can provide objective information regarding respiratory shape. Use of this instrumentation allows the SLP to substantiate observations of inconsistent lung volume levels (i.e., the patient initiates speech at varying lung volume levels), inappropriate lung volume levels (i.e., the patient initiates speech below the desired lung volume level), and excessive lung volume levels (i.e., the patient initiates speech above the desired lung volume level) (Yorkston et al., 1999). Furthermore, McHenry & Minton (1998) address specific factors to consider when instrumentally evaluating speech breathing in speakers who are difficult to assess due to physiologic or cognitive problems.

Phonatory Function

Another main aspect of a respiratory/phonatory system evaluation might be a laryngeal examination based on suspected phonatory involvement. A formal laryngeal assessment should be conducted when structural lesions or lesions of the vagus nerve are a possibility

(Duffy, 1995) or prior to intensive voice therapy, such as the Lee Silverman Voice Treatment program (Ramig, Countryman, Fox, & Sapir, in press).

### Clinical Screening

Before discussing instrumental laryngeal assessment, several informal screening methods for judging the integrity of the larynx will be highlighted:

- **Maximum phonation time** is often used as a global assessment of phonatory capacity, but the caveats discussed earlier, such as the pulmonary-laryngeal interaction and the strong presence of age effects, pertain here as well (Kent, 1997a). Nonetheless, Robin and colleagues (1997) note that sustained phonation may provide information on membranous vocal fold closure patterns (Verdolini, 1994); that is, maximum phonation times are decreased when conditions such as vocal fold bowing prevent complete closure.
- Performance on the **S:Z ratio** may provide a gross method for differentiating respiratory from phonatory dysfunction. If both subsystems are functioning within normal limits, the s:z ratio should be slightly less than one. Ratios greater than one are interpreted as involvement at the laryngeal level. Reductions of both /s/ and /z/ tend to implicate the respiratory system. However, as noted by Robin et al. (1997), the reductions might also stem from ineffective vocal tract constriction thus proving problematic for subsystem isolation.
- **Laryngeal diadochokinesis** (repeating a vowel as rapidly as possible) may serve as an index of the neural integrity of the phonatory system (Verdolini, 1994 in Robin et al., 1997). Verdolini recommends that SLPs obtain measures of rate, loudness and clarity over time; strong consistent productions are indicative of normal phonatory functioning. Data on reliability or sensitivity in detecting phonatory problems are not currently available (Robin et al., 1997).
- Asking patients to systematically **vary pitch** and loudness provides a general indicator of phonatory range and control (Kent, 1997a; Robin et al., 1997). Laryngeal control can also be roughly estimated by evaluating the speaker's ability to produce voiced versus voiceless contrasts (Yorkston et al., 1999).
- Finally, the gross integrity of laryngeal adduction can be inferred from the sharpness of a patient's **cough and glottal coup** (Duffy, 1995). As noted by Duffy, a weak cough but sharp glottal coup may reflect respiratory weakness, whereas a weak coup but normal cough (or equally weak cough and coup) tends to be associated with laryngeal weakness or combined laryngeal and respiratory weakness.

### Instrumental Measures

Instrumental assessment of phonatory dysfunction can be conducted in consultation with an otolaryngologist by direct or indirect methods (see Thompson-Ward and Murdoch, 1998; Duffy, 1995). Methods that allow direct visualization of the larynx include:

- Endoscopy
- Videostroboscoopy
- High-speech photography
- Optically precise rigid laryngoscopes
- Flexible fiberoptic laryngoscopy.

Indirect methods also can provide essential information regarding vocal cord activity. For example, aerodynamic measures have demonstrated utility in documenting perceptual voice characteristics and differentiating speakers with hypokinetic dysarthria (Gracco, Gracco, Lofqvist, & Marek, 1994). Examples of indirect methods include:

- Photoglottography
- Electroglottography
- Spectrographic/acoustic analyses
- Laryngeal aerodynamics
- Indirect mirror laryngoscopy

### Follow-up with Progressive Disorders (Figure 5B)

When assessment results suggest adequate respiratory/phonatory functioning for the needs and desires of the patient, the management of those subsystems is typically discontinued. However, there are several progressive disorders for which the onset of respiratory and/or phonatory difficulties is likely during the course of the disease. Patients with diseases such as amyotrophic lateral sclerosis, Huntington disease, Parkinson disease, multiple sclerosis, and Friedreich's ataxia should be monitored on a routine basis for the emergence of respiratory/phonatory decline. Monitoring the respiratory status of individuals with ALS, in particular, is critical in the staging of interventions; failure of the respiratory system is the most common cause of death in this disease (Yorkston, Strand & Miller, 1996). The frequency of the screenings would be contingent upon numerous factors, including the rapidity with which the disease was progressing and the level of concern of the patient.

### Management of Reduced Function (Figure 5C)

If the results of the respiratory/phonatory assessment indicate reduced function, decisions must subsequently be made regarding treatment candidacy and treatment focus. The symptoms of respiratory/phonatory impairment may be categorized as reductions in: (1) respiratory support, (2) respiratory/phonatory coordination and control, and/or (3) phonatory functioning. These three areas will serve as an organizing framework for clinical decision-making in the management of the respiratory/phonatory aspects of speech.

Before discussing treatment in each of these areas, a brief review of general principles of intervention is provided. Although studies of motor learning often often focused on movements of the upper limbs (Schmidt, 1991), increasing attention has been placed on principles of motor learning as related to speech (Adams & Page, 2000; Schulz, Sulc, Leon, & Gilligan, 2000) and designing effective intervention activities (Ramig, Pawlas, & Countryman, 1995; Yorkston et al., 1999). Generally, an effort is made to provide the client with substantial and systematic practice opportunities because occasional or inconsistent practice is usually not sufficient to develop and refine the motor learning. Knowledge of results or feedback about the adequacy of performance is an important means of enhancing motor learning. The literature contains many examples of biofeedback as a valuable tool for providing information to a patient on the functioning of their respiratory/phonatory mechanism (Dworkin & Meleca, 1997; Johnson & Pring, 1990; Ramig, Pawlas et al., 1995; Volin, 1998).

## Improving Respiratory Support

Patients found to have inadequate breath support for speech may benefit from treatments designed to improve respiratory drive. This is often the case in severe flaccid dysarthria. Use of nonspeech tasks, postural adjustments, prosthetic assistance, and speech tasks are described.

### Nonspeech Tasks (Figure 5D)

Generally, intervention focusing on nonspeech actives is limited to speakers unable to generate adequate subglottal air pressure to support phonation. Nonspeech tasks are typically unnecessary and inappropriate for patients who can perform speech exercises to accomplish the treatment goal (Duffy, 1995). However, for particularly severe patients, nonspeech respiratory tasks that isolate breathing may serve as an essential building block for future speech production. It is important to note though that the generalization of nonspeech activities to speech production is predictably challenging (Gerratt, Till, Rosenbek, Wertz, & Boysen, 1991). To facilitate the likelihood of generalization, the transition from nonspeech to speech tasks should be made as quickly as possible. Some successful programs for improving respiratory support, such as the Lee Silverman Voice Treatment program by Ramig and colleagues, establish a behavior in a nonspeech activity then move to speech production within each session.

Historically, therapy targeting the strengthening of respiratory muscles was most frequently reported for children with cerebral palsy. Early therapy approaches for this population consisted of techniques such as blowing out matches; blowing balloons, bubbles, harmonicas, and feathers; placing a flat sandbag on the supine child's abdomen to increase rib excursions (Blumberg, 1955); applying pressure with thumbs by pushing up and under the rib cage to stimulate the diaphragm; "vibrating" on the patient's diaphragm, ribs, spine, etc.; placing a cube of ice above the diaphragm to provide proprioceptive stimuli (Hoberman & Hoberman, 1960); and electrical stimulation (Jones, Hardy, & Shipton, 1963). Many of these early studies were able to demonstrate some improvement in vital capacity, but suffered from a lack of speech outcome measures (Solomon & Charron, 1998) and methodological rigor.

There are potential benefits that might be achieved from direct focus on the respiratory subsystem. Increasing vital capacity and endurance for breathing may result in the ability to produce more syllables on one breath and talk for longer periods of time, assuming laryngeal, velopharyngeal and upper articulator valving is adequate (Solomon & Charron, 1998). The following techniques have demonstrated clinical utility for improving respiratory support:

- Controlled exhalation tasks (Brookshire, 1992; Murry & Woodson, 1995; Ramig & Dromey, 1996; Ramig, Pawlas et al., 1995)
- Maximum inhalation and exhalation tasks (Ramig & Dromey, 1996; Ramig, Pawlas et al., 1995)[1]
- Pushing and pulling techniques (Workinger & Netsell, 1992)
- Breathing against resistance through:
    - a simple water manometer or blow bottle (Daniel-Whitney, 1989; Hixon et al., 1982; Netsell & Daniel, 1979; Workinger & Netsell, 1992)
    - a resistive mask (Cerny, Panzarella, & Stathopoulos, 1997)
    - pursed lips (Solomon & Charron, 1998)
- Using an air pressure transducer with feedback from an oscilloscope or computer screen.
- Sustaining phonation with feedback from Visipitch or the VU meter on a tape recorder.

Hixon, Putman, and Sharp (1983) provided information regarding compensatory breathing strategies (neck breathing and glossopharyngeal breathing) for patients with flaccid paralysis of the rib cage, diaphragm, and abdomen. As Duffy (1995) notes, however, these strategies may be limited to patients with isolated respiratory impairments, and should be cleared by a physician knowledgeable about pulmonary function prior to implementation.

<u>Postural Adjustments (Figure 5E)</u>

Body positioning can have a marked influence on respiratory support for speech. The behavior of the breathing apparatus differs substantially depending on body position (Hoit, 1995). Thus, postural adjustments or correct positioning, particularly in patients who are wheelchair-bound, can be a simple yet effective measure for improving the respiratory drive for speech (Horton et al., 1997). The nature of the postural adjustments

[1] Ramig and colleagues have demonstrated greater treatment effects for a combined respiratory/phonatory treatment approach versus a respiratory-only treatment in persons with Parkinson disease.

will depend on many factors, including the degree of the patient's inspiratory versus expiratory difficulty, the level of the patient's voluntary motor control, and the concomitant medical/physical difficulties.

Patients with significant inspiratory problems may perform best in the upright position because gravity can assist in lowering the diaphragm into the abdomen upon inspiration (Duffy, 1995). Inspiratory difficulties are often encountered, for example, in patients with amyotrophic lateral sclerosis and obstructive lung disease (Yorkston et al., 1999). By extension, patients with Parkinson disease may experience limited respiratory support due, in part, to the characteristic hunched-forward position. Facilitating an upright position in these patients may optimize their speech breathing.

Expiratory difficulties are encountered, for example, in patients with traumatic brain injury, spinal cord injury, and multiple sclerosis. Patients with greater expiratory than inspiratory difficulty for speech may benefit from the supine position because gravity and abdominal contents help to push the diaphragm into the thoracic cavity to assist expiration (Netsell & Rosenbek, 1985). Appropriate positioning for adequate physiologic support can be accomplished using adjustable beds and wheelchairs, and chairs with adjustable backs (Yorkston et al., 1999). Supine positioning has also been used therapeutically with patients with cerebral palsy to minimize spasticity (Solomon & Charron, 1998). Adaptive seating systems have been found to enhance pulmonary function in children with cerebral palsy by minimizing abnormally active postural muscles (Nwaobi & Smith, 1986; Reid & Sochaniwskyj, 1991). The trade-off of supine positioning, however, is that inspiratory ability will be diminished. Moreover, the use of positions other than upright to train speech breathing has been criticized. According to Hoit (1995), the change in body position from supine to upright dramatically alters the mechanical characteristics of the respiratory system and impedes generalization across body positions.

The long history of position modifications for children with cerebral palsy (e.g., head and trunk control and alignment; sitting postures) has been motivated, in part, by a Neurodevelopmental Treatment (NDT) framework (Redstone, 1991). However, reviews of the literature suggest that efficacy of NDT on breathing or speech has not been studied (Solomon & Charron, 1998).

<u>Prosthetic Assistance (Figure 5F)</u>

In some cases, prosthetic devices may be necessary to supplement expiratory forces during speech. The two primary forms of prosthetic assistance are expiratory boards/ paddles and abdominal binders/corsets/braces. These types of assistive devices may be evaluated in consultation with a physical therapist.

<u>Expiratory boards or paddles</u> provide a stationary object for the patient to lean into while speaking, thus increasing expiratory force. The boards can be mounted on a wheelchair and swung into position when necessary to increase respiratory drive for speech

(Rosenbek & LaPointe, 1985). Because patients can lean back away from the board, this approach does not interfere with inhalation (Yorkston & Kennedy, 1999). Clinicians can determine candidacy for an expiratory board by placing a hand on the patient's abdomen and applying varying amounts of pressure during inhalatory and exhalatory portions of the respiratory cycle for speech (Rosenbek, 1984). As discussed by Rosenbek, demonstrable improvement in overall loudness or loudness patterns suggests that a board/paddle may be appropriate as a short-term treatment while physiologic recovery is occurring, or permanently if a speaker fails to regain neuromotor control. Patients requiring the assistance of an expiratory board, however, commonly lack adequate trunk strength or balance to use it properly (Yorkston et al., 1999). An alternative approach that may benefit some patients with adequate arm strength is to push in on the abdomen with one hand during expiration (Duffy, 1995).

For patients who do not have the upper torso motor control to use an expiratory board, an abdominal binder or corset may be considered. Abdominal binders are used to help support weak abdominal muscles, enhance posture, and enable more efficient speech breathing. Ideal candidates for this form of treatment typically have intact diaphragmatic function but weak expiratory muscles, which tends to occur more often in patients with spinal cord injury (Yorkston et al., 1999) and some children with cerebral palsy (Solomon & Charron, 1998). The risk of abdominal binding, however, is that it may restrict inspiration and cause pneumonia (Rosenbek & LaPointe, 1985), and it is ineffective and potentially dangerous for patients with inspiratory weakness (Yorkston et al., 1999). As such, medical approval and supervision are essential when abdominal binders are being used, and extended use should be limited (Duffy, 1995). A case study was reported by Simpson, Till and Goff (1988) of a patient with severe dysarthria who used an abdominal binder at the outset of treatment. The prosthetic assistance resulted in increased speech intensity (but with considerable variability) and increased vital capacity. However, due to continued periods of cessation of respiration, alternative treatment approaches were subsequently implemented.

Speech Tasks (Figure 5G)

Improvements in respiratory support are most ideally targeted during actual speech production. The focus of these treatment approaches is varied, but generally can be grouped as modification of the inhalatory/exhalatory pattern and biofeedback.

Manipulations of breathing patterns during speech production can provide a means of improving respiratory support. Some patients may simply need to practice inhaling more deeply or using more force when exhaling during speech (Hammen & Yorkston, 1994; Ramig, 1986; Ramig, Pawlas et al., 1995). As deeper inhalations generate more forceful elastic recoil of the lungs, patients with weak respiratory systems may have excessive loudness bursts or rapid air wastage if the higher expiratory pressures are unchecked during exhalation (Duffy, 1995). Netsell (1998) noted the importance of maintaining stable pressures throughout the breath group, and has described a treatment strategy for producing stable subglottal air pressure. "Inspiratory checking" (Netsell, 1992; Netsell, 1995) is performed by asking the patient to inhale to approximately 50% of their maximum capacity and then to "let the air out slowly" when talking. By extension, patients may also practice sustaining isolated sounds for five seconds while keeping intensity and quality constant (Rosenbek & LaPointe, 1985). Another method for enhancing respiratory support for speech is abdominal or diaphragmatic breathing, which affords the greatest lung volumes and subsequently increases abdominal contributions during speech (Thompson-Ward et al., 1997).

Various forms of biofeedback can be utilized to allow patients to gauge both respiratory force and ability to maintain consistent subglottal air pressure. Output from air pressure transducers can be displayed on an oscilloscope for patients to work toward the targeted air pressure levels. Yorkston et al. (1999) reported using this method with patients with traumatic brain injury who demonstrated difficulty maintaining consistent air pressure levels or who produced excessively large air pressure values during speech. Air pressure can be monitored with a pressure-sensing tube placed in the corner of the patient's mouth. Once respiratory support for sustained phonation is established, speech stimuli can progress from speech-like items, such as repetition of syllables, to utterances of increasing length. Utterances should be constructed with ample tokens of the phoneme /p/ to allow adequate monitoring of air pressure (Yorkston et al., 1999). Although not as precise an outcome measure, systems such as VisiPitch or even the VU meter on a tape recorder can be used to target specific loudness levels during speech production or sustained phonation. Numerous studies have reported improvement of various aspects of respiratory support from biofeedback therapy (McNamara, 1983; Murdoch et al., 1999) (McNamara, 1983; Murdoch et al., 1999; Ramig and Dromey, 1996; Ramig et al., 1995; Simpson et al., 1988; Thompson-Ward et al., 1997). It is worthwhile to note, however, that candidacy for biofeedback therapy may be influenced by the patient's level of stimulability. Volin (1998), in a study of biofeedback for respiratory rate control, found that individuals who are likely to benefit from biofeedback include those whose stimulability levels are in the low to middle ranges. Patients with high levels of stimulability actually showed a large decrement in performance after receiving biofeedback training.

As indicated earlier, generalization will be enhanced considerably if the tasks outlined for nonspeech, postural and prosthetic treatment approaches incorporate speech stimuli as soon as possible. For instance, the pushing/pulling techniques described in the "nonspeech tasks" section may be employed initially with the patient producing only breath or undifferentiated vowels. Speech stimuli should then progress in a timely manner to differentiated vowels and syllables and should, for appropriate patients, culminate with connected speech.

### Improving Coordination/Control

Some individuals with dysarthria, particularly those with ataxia or involuntary respiratory/phonatory movements, are unable to manage their respiratory and phonatory systems appropriately during speech. For example, they may initiate utterances at inappropriate or inconsistent lung volume levels. When this is the case, the goal of intervention is to stabilize the respiratory pattern during speech.

Nonspeech Tasks (Figure 5H)

Many of the nonspeech tasks for improving respiratory coordination and control derived from the treatment of children with cerebral palsy. Blumberg (1955) reported using nonspeech techniques such as matching the rate of respiration to the ticking of a metronome to develop regular breathing rate and rhythm. More recently, Solomon and Charron (1998) identified nonspeech strategies for improving the respiratory coordination of children with cerebral palsy by:

- Rehearsing a speech-like breathing pattern (i.e., quick inspirations and slow, controlled expirations)
- Implementing “inspiratory checking” (Netsell, 1992) without accompanying speech (if it is problematic for the patient to speak on controlled exhalations)
- Facilitating inspiratory coordination and speed through sniffing, or exhalatory coordination through blowing
- Practicing switching between inspiration and expiration; the speed of the task can eventually be increased to resemble panting[2]

The above techniques are not restricted to patients with dysarthria from cerebral palsy; similar strategies have been suggested for use with other patient populations, such as individuals with spastic dysarthria (Thompson, Murdoch, & Theodoros, 1997) and mixed dysarthria (Murdoch et al., 1999). Murdoch et al.(1999) implemented nonspeech tasks as part of the respiratory treatment for a child with persistent dysarthria following severe traumatic brain injury. A single-subject experimental design was used to compare traditional versus biofeedback therapy. Techniques such as instruction of an effective breathing pattern were implemented during the traditional therapy, while the use of Respitrace to increase control of inhalation and exhalation was part of the biofeedback therapy. Instrumental outcome measures indicated that biofeedback techniques were superior to the traditional therapy strategies.

Caveats regarding nonspeech tasks that were outlined in the previous discussion of respiratory support treatment apply here as well. Specifically, nonspeech tasks are often inappropriate for patients who can perform speech exercises and should be modified to include speech stimuli as soon as possible to promote generalization to speech production.

[2] The authors note, however, that this requires considerable coordination and precision of movement and may therefore be impractical for many children with cerebral palsy.

Speech Tasks (Figure 5I)

Patients who experience difficulty with respiratory/phonatory coordination or control may benefit from improved awareness of the speech-breathing pattern, i.e., quick inspiration followed by prolonged exhalation during speech production. Patients may need to modify how much air is inhaled prior to speaking and may need to learn how to control air use during speaking. Teaching patients to evaluate and monitor loudness level during speech is an important first step in recognizing inappropriate loudness or loudness changes (Rosenbek, 1984). Instrumental feedback from Respitrace and magnetometers, for example, also can be particularly useful for demonstrating the desired breathing pattern. Water spirometry has also been used; however, individuals with dysarthria often have difficulty speaking into the closed system of the water spirometer during treatment (Yorkston et al., 1999). If necessary, the clinician can place one or both hands on the patient's abdomen and combine pressing movements with instruction about getting to the "right size" during inhalation/exhalation (Rosenbek, 1984). The speech stimuli for these exercises can range from syllables or simple words to complex sentences; stimuli of graded difficulty should be employed to encourage respiratory/phonatory control over progressively more propositional utterances. Candidates for treatment strategies of this nature include patients who:

- Initiate speech at variable points in the respiratory cycle and need more consistent inspiratory control (Duffy, 1995)
- Initiate speech at inappropriate lung volume levels and need to vary the depth of consecutive inhalations (Rosenbek, 1984; Yorkston et al., 1999)
- Terminate speech late in the expiratory cycle with resultant diminished loudness (Yorkston et al., 1999)
- Exhibit abnormal or maladaptive respiratory patterns, such as speaking on inhalation and forced expiration, often seen in patients with hyperkinetic dysarthria (Klasner, 1995) or patients with a concomitant cognitive impairment (Yorkston et al., 1999).
- Adopt a fatiguing pattern of breathing, such as excessive shoulder elevation (Yorkston et al., 1999)

By extension, speakers can be instructed to use "optimal breath groups" (Linebaugh, 1983), that is, the number of syllables that can be produced comfortably on one breath. Once a baseline is established, the targeted length of phrases and sentences uttered in a single breath group can be gradually increased to encourage respiratory control. If the speaker exhibits a marked cognitive impairment, the clinician might instead train inhalation during the first syllable of every utterance (Yorkston et al., 1999).

As discussed in the respiratory support section, inspiratory checking is a technique for controlling the flow of air through the larynx by countering the elastic recoil forces of the respiratory system (Netsell, 1992). This strategy may prove useful for speakers who release excessive airflow through the larynx when they speak (Netsell, 1995). The ability of the patient to “check” recoil pressures also must be considered when training speakers to generate higher lung volume levels (i.e., patients should only inhale to a lung volume level for which they are sufficiently able to use the inspiratory muscles to offset the elastic recoil).

Yorkston and colleagues (1999) provide suggestions regarding the training of respiratory flexibility. Normal speakers will vary their inhalation depth depending on the length and volume of the intended utterance. If the demonstrated speech-breathing pattern of the patient suggests an inability to vary depth of inhalation, several treatment strategies are suggested:

- <u>Conceptual training</u>. The patient is first taught general rules that govern respiratory performance during speech. The speaker can then practice reading paragraphs in which the respiratory patterns or breath group boundaries have been marked.
- <u>Cued conversational scripts</u>. Conversational scripts for two speakers are prepared. The patient can practice modifying inhalations according to the marked respiratory patterns while speaking with another person.
- <u>Uncued reading/conversation</u>. The patient reads aloud or speaks conversationally without the aid of respiratory pattern markings.

In sum, there are numerous strategies available for increasing the coordination and control of the respiratory/phonatory system, many of which entail the patient’s awareness of the deficit and some form of auditory, visual or, occasionally, tactile feedback. Effective techniques for improving respiratory/phonatory coordination and control using such strategies have been delineated in the research literature (e.g., Murdoch et al., 1999; Thompson-Ward et al., 1997; Workinger and Netsell, 1992).

## <u>Improving Phonatory Function</u>

Although respiratory and phonatory systems perform as a unit, for some speakers with dysarthria, intervention focuses on improved phonatory function.

### <u>Hypoadduction (Figure 5J)</u>

A breathy voice may indicate air wastage and signal hypoadduction of the vocal folds. Speakers with unilateral or bilateral vocal fold weakness from muscle or nerve damage would typically manifest hypoadduction. Techniques for enhancing vocal fold adduction using physical strategies, and increased loudness as a trigger for better speech, are described below. These techniques are particularly useful for individuals with laryngeal paresis or glottal incompetence (e.g., from bowed vocal folds) including TBI with brainstem contusion, brainstem stroke, Parkinson disease, Progressive Supranuclear Palsy, and Shy-Drager syndrome (Yorkston et al., 1999).

Physical Strategies to Enhance Adduction (Figure 5K)

There are various physical strategies that can be implemented to address phonatory impairment from vocal fold hypoadduction. These strategies fall under the broad categories of effort closure techniques, postural adjustments, and physical manipulations.

Effort closure techniques are exercises that increase the adductory forces of the vocal folds by modifying background of effort. First described by Froeschels in 1943, they are thought to maximize vocal fold adduction and may ultimately improve vocal fold strength (Duffy, 1995) resulting in increased loudness and reduced breathy/hoarse quality (Ramig, 1995). Examples of effort closure techniques include:

- Clasping hands together and squeezing palms together as hard as possible (Aronson, 1990; Dworkin & Meleca, 1997; Yamaguchi et al., 1993)
- Interlacing hands and pulling outward (Yamaguchi et al., 1993)
- Pushing down on the speaker's raised arms in a rapid, uninterrupted motion (followed by the speakers doing the same motion unassisted) (de Angelis et al., 1997)
- Sitting in a chair, grasping the bottom with both hands, and pulling upward (Aronson, 1990; Dworkin & Meleca, 1997)
- Sitting in a chair and pushing down on the seat bottom with both hands (Aronson, 1990; Dworkin & Meleca, 1997)
- Pushing against a lap board, the arms of a wheelchair, or against any other firm surface (Rosenbek, 1984)
- Pushing the head forward against resistance provided by the examiner's hands placed on the forehead of the speaker (Yamaguchi et al., 1993)
- Grunting and controlled coughing (to elicit phonatory behavior) (Duffy, 1995; Ramig, Pawlas et al., 1995)

A broad spectrum of speech stimuli can be used during implementation of these effort closure techniques. The nature of the stimuli will depend upon the characteristics and abilities of the individual speaker, and can range from sustained phonation to conversational discourse. As illustrated by Yamaguchi et al. (1993), it may be appropriate with a speaker to begin training the technique with basic stimuli, such as vowels, and progress to diphthongs, syllables, sentences and connected speech as the speaker meets criterion for success at each level. Yamaguchi and colleagues examined the efficacy of the effort closure (pushing) technique in three case studies. Physiological, acoustic and perceptual analyses revealed that effort closure techniques may improve glottic closure and phonation in certain speakers, and specifically highlighted the effectiveness of these techniques for unilateral vocal fold paralysis 3-6 months after onset. The authors note, however, that some limitations or drawbacks associated with effort closure techniques should be considered. Specifically, (1) laryngeal irritation occasionally occurs as a result of the excess effort, (2) extraneous compensatory movements may develop in some speakers, and (3) generalization to connected speech may not occur with the pushing technique alone and might require the use of additional carry-over exercises. Solomon and Charron (1998) additionally note that effort closure techniques should be used judiciously for speakers with spastic muscles from cerebral palsy, and recommend combining these techniques with relaxation and muscle lengthening procedures.

Related to effort closure techniques is the hard glottal attack, i.e., driving the vocal folds together with forceful, abrupt phonatory efforts. As discussed by Dworkin and Meleca (1997), this technique should be done with limitations in order to prevent the possibility of short-term abusive side effects, and should only be incorporated with speakers who have failed to improve with other approaches. Speakers trained with this approach may benefit from tactile feedback (i.e., externally-applied abdominal pressure; Dworkin and Meleca, 1997) or various forms of biofeedback from VisiPitch, a stethoscope (Dworkin and Meleca, 1997), or videoendoscopy (Ramig, 1995).

<u>Postural adjustments</u> have also been cited as a behavioral strategy for treating speakers with hypoadduction (Aronson, 1990; Duffy, 1995; Ramig, 1995; Yorkston et al., 1999). The primary strategy suggested for speakers with vocal fold weakness is to turn their head to the left or right during phonation. This postural change can increase the tension of the paretic/paralyzed fold (Ramig, 1995). However, head turning can be considered a pragmatically undesirable solution to the hypoadduction and may not lead to any true improvement in vocal fold adduction (Rosenbek and LaPointe, 1985). Duffy (1995) suggests that head turning should be considered compensatory and perhaps reserved for occasions when there is a situational demand for increased loudness.

<u>Physical manipulations</u> of the thyroid cartilage are occasionally used to improve vocal quality and loudness in speakers with hypoadduction. The external compression of the larynx is thought to achieve medialization of the vocal fold on the side of stimulation (Dworkin and Meleca, 1997; Ramig, 1995). This technique requires the speech-language pathologist to gently push on the larynx while the speaker phonates. It has been used to successfully elicit voicing from two speakers with whispered phonation following TBI (Sapir & Aronson, 1985). However, positive results from laryngeal compression in chronic conditions should prompt consideration of surgical treatment options, such as vocal fold repositioning or medialization (Dworkin and Meleca, 1997). As with head turns, digital manipulations of the thyroid cartilage may not effectively alter the true functioning of the vocal folds. Additionally, speakers often resist using this technique during conversation because of its unusual appearance (Yorkston et al., 1999). As such, it should perhaps be considered more as a compensation for situations that require a transitory increase in loudness (Duffy, 1995).

Trigger Better Speech with Increased Loudness (Figure 5L)

Reduced speech loudness is one of the more common perceptual features of hypokinetic dysarthria associated with Parkinson disease. Achieving the goal of increasing loudness may also serve to trigger other speech benefits including improved articulation (Dromey, Ramig, & Johnson, 1995). One of the best-documented treatments for improving phonatory function is the Lee Silverman Voice Treatment (LSVT). LSVT is an intensive behavioral treatment program developed by Ramig and colleagues (Ramig, Pawlas et al., 1995) to improve the oral communication of speakers with hypokinetic dysarthria. The general goals of LSVT are to increase overall intelligibility by (1) improving phonation, (2) increasing vocal loudness and (3) increasing sensory self-monitoring of vocal effort. Five essential concepts form the basis for treatment delivery:

- Voice focus: "Think Loud" is used as the system trigger for improving vocal effort
- High phonatory and physical effort: Increased effort is needed to override rigidity and hypokinesia
- Intensive treatment: Daily practice opportunities are requisite; treatment is administered four times a week for 16 sessions in one month
- Sensory calibration/perception: Speaker learns to identify the appropriate amount of effort
- Quantification: Quantified feedback by the clinician is key to motivating speakers

Ramig and colleagues have conducted a series of studies to demonstrate the efficacy of LSVT, and continue to investigate the use of LSVT in patients with Parkinson disease and other neurologic disorders. Below is summary of the evolution of the research on LSVT:

| | |
|---|---|
| Countryman and Ramig (1993) | Case study of the effectiveness of LSVT in a speaker with mixed hypokinetic-spastic dysarthria from Parkinson disease with bilateral thalamotomy |
| Ramig, Bonitati, Lemke, and Horii (1994) | Demonstrated the effectiveness of LSVT in 40 speakers with dysarthria from Parkinson disease |
| Countryman, Ramig, and Pawlas (1994) | Demonstrated the effectiveness of LSVT in 3 speakers with Parkinsonian Plus syndromes (multiple system atrophy, Shy-Drager syndrome, and Progressive Supranuclear Palsy) |
| Dromey, Ramig, and Johnson (1995) | Case study of the effectiveness of LSVT in a speaker with dysarthria from early-stage Parkinson disease |

| | |
|---|---|
| Ramig, Countryman, Thompson, and Horii (1995) | Demonstrated the superiority of LSVT over respiratory-only therapy in a randomized group study of 45 speakers with Parkinson disease |
| Smith, Ramig, Dromey, Perez, and Samandari (1995) | Reported the superiority of LSVT over respiratory-only therapy in improving laryngeal adduction and vocal intensity in 22 speakers with Parkinson disease |
| Ramig and Dromey (1996) | Demonstrated greater aerodynamic and adductory changes using LSVT versus respiratory-only treatment in 17 speakers with Parkinson disease |
| Ramig, Countryman, O'Brien, Hoehn, and Thompson (1996) | Found better long-term maintenance of treatment effects using LSVT versus respiratory-only treatment in 35 speakers with Parkinson disease |
| Countryman, Hicks, Ramig, and Smith (1997) | Case study of the effectiveness of LSVT in a speaker with true vocal fold hypoadduction and supraglottic hyperadduction from Parkinson disease |
| Theodoros, Thompson-Ward, Murdoch, Lethlean, and Silburn (1999) | Demonstrated the effectiveness of LSVT in a speaker with severe hypokinetic dysarthria from Parkinson disease and thalamotomy/pallidotomy surgery |
| Ward, Theodoros, Murdoch, and Silburn (2000) | Reported more global effectiveness of LSVT in speakers with PD who had not undergone surgical treatment |
| Ramig, Sapir, Fox, and Countryman (2001) | Established that the effects of LSVT are treatment specific and not related to extraneous factors by comparing treated and untreated speakers with Parkinson disease and age-matched controls |
| Sapir, Pawlas, Ramig, Seeley, Fox, and Corboy (2001) | Found LSVT to be effective in two speakers with vocal weakness and fatigue from multiple sclerosis |
| Solomon, McKee and Garcia-Barry (2001) | Case study of the effectiveness of LSVT combined with respiration treatment and physical therapy in a speaker with hypokinetic-spastic dysarthria from traumatic brain injury |
| Baumgartner, Sapir, and Ramig (in press) | Demonstrated the superiority of LSVT over respiratory-only therapy for improving vocal quality in a randomized group study of 20 speakers with Parkinson disease |

The effectiveness of LSVT is well established in speakers with dysarthria from mild to moderate Parkinson disease. At present, there is less evidence to support the long-term efficacy of LSVT for speakers with severe Parkinson disease or other forms of basal ganglia disruption. Research on the use of LSVT with other neurologic disorders, such as MS and TBI, is promising, but it is premature to draw conclusions regarding efficacy in these clinical populations.

Hyperadduction (Figure 5M)

Hyperadduction of the vocal folds often occurs as the result of upper motor neuron system disorders, such as spastic dysarthria and spastic cerebral palsy, and hyperkinetic disorders of the basal ganglia control circuit, such as Huntington disease and adductor laryngeal dystonia (Ramig, 1995; Yorkston et al., 1999). Hyperadduction may also occur as a compensatory mechanism for managing weakness at the laryngeal or velopharyngeal level. The resulting vocal quality is often characterized as harsh, strained-strangled, hoarse, or pressed.

Nonspeech Techniques (Figure 5N)

Behavioral treatment of voice quality often is not undertaken because it is quite difficult to modify and may result in a negligible improvement of intelligibility (Duffy, 1995). If the dysphonia is felt to contribute to the speaker's overall disability, traditional voice techniques designed to reduce laryngeal hyperadduction and increase airflow through the glottis may be appropriate (Pannbacker, 1998; Yorkston et al., 1999).[3]

Nonspeech behavioral techniques for improving hyperadduction are generally comprised of relaxation strategies and biofeedback of airflow or the laryngeal muscles. Various forms of muscle relaxation have been noted in the literature, including

- Head, neck, and jaw musculature relaxation exercises, such as the "rag doll" and "chewing" techniques (Dworkin & Meleca, 1997)
- Gentle massage of the larynx and interconnecting strap musculature (Aronson, 1990; Dworkin & Meleca, 1997; Rosenbek & LaPointe, 1985)
- Progressive whole body relaxation (Jacobson, 1976; McClosky, 1977; Ramig, 1995)

The success of traditional relaxation procedures for improving hyperadduction from a dysarthria is inconsistent (Yorkston et al., 1999). To date, no studies demonstrating the efficacy of muscle relaxation or massage are available.

Several types of biofeedback may be used to address dysphonia from hyperadduction. Dworkin and Meleca (1997) suggest using VisiPitch to provide biofeedback of nonvocal airflow control. Speakers are asked to maintain a steady and controlled stream of air; therapeutic gains may translate into reduced glottal airflow resistance and enhanced respiratory support. Furthermore, to provide speakers with information on the level of laryngeal muscle tension, electromyographic and videoendoscopic feedback have been suggested (Ramig, 1995). There is no research available to support nonspeech biofeedback treatments for hyperadduction from a dysarthria.

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[3] A separate module of the Practice Guidelines for Dysarthria will address medical interventions for voice/ laryngeal impairments associated with the dysarthrias.

Speech Tasks (Figure 5O)

Speech tasks for addressing hyperadduction tend to focus on traditional tension-reducing strategies and biofeedback-enhanced relaxation. Traditional approaches to reducing laryngeal tension during speech include strategies for easy onset of phonation, such as the 'yawn-sigh", "chewing", or "chanting" techniques (Darley, Aronson, & Brown, 1975; Dworkin & Meleca, 1997). As discussed by Ramig (1995), these approaches are based on the hypothesis that phonation produced in the context of "reflex-like" or "continuous phonation" responses, it will be more relaxed with less hyperadduction. The relaxed phonation can then be shaped into a relaxed vowel and through the hierarchy to conversational speech. Murry and Woodson (1995) conducted effort-reducing voice therapy on a group of speakers with extrinsic muscle hyperfunction and airflow abnormalities following Botox injection. The investigators found that speakers who received both Botox treatment and behavioral therapy demonstrated improved phonation in terms of increased airflow rate and acoustic measures.

Biofeedback during speech may help speakers monitor levels of extrinsic laryngeal muscle tension. This feedback can be electromyographic, videoendoscopic, or aerodynamic. Visual biofeedback of vocal fold vibrations would allow the speaker to practice modifying phonatory behaviors during vowel exercises. If airflow transducers are not available to provide aerodynamic biofeedback of transglottal airflow rate, Dworkin and Meleca (1997) suggest using the See Scape device (Pro-Ed). Speakers are instructed to practice easy voice initiation and control and to continuously strive for low levels of laryngeal muscle tension. A progressive hierarchy can be implemented from vowels, to syllables, words, sentences, and ultimately conversation.

For speakers with spasticity from cerebral palsy, it may help to move the speaker's head from side to side or forward and backward while the speaker vocalizes quietly (McDonald, 1987 in Solomon and Charron, 1998). McDonald warns, however, that vocalization should be limited because the speaker is apt to develop tension and lose the ability to control the phonation as lung volume decreases. By extension, it has been suggested that a strained voice quality can be improved if pitch is increased, the head is rotated back and the utterance is initiated at a high lung volume (Yorkston et al., 1999). These behaviors are associated with decreased airway resistance (Ramig, 1995).

No studies are available to document the effectiveness of biofeedback or postural adjustments in reducing hyperadduction from a dysarthria.

Measurement of Outcomes (Figure 5P)

Treatment outcomes can be measured in a variety of ways. As discussed in the first section of this report, the International Classification of Function (ICF) provides a scheme for organizing the consequences of chronic conditions such as dysarthria (International Classification of Function, Disability and Health, 2001). To reiterate, impairments are problems in the physiological function of the body systems. In dysarthria, this would include changes in respiratory or phonatory function. Activity is the execution of a task or action by an individual; in dysarthria, the activity is speaking. Participation is involvement in a life situation. Applying the term to dysarthria, measures of participation reflect involvement in life situations that include speaking.

Examples from the literature of specific outcome measures are outlined below under the categories of measures of impairment and measures of activity/participation. The focus of the outcome measures varies as a function of the type of intervention. Thus, the primary outcome measures are different when the treatment involves improving respiratory support, coordination/control or phonatory function.

Improved respiratory support

When the goal of intervention is to improve respiratory support for speech, outcome measures may reflect either physiologic or perceptual aspects of the speech impairment or overall speech adequacy during activities and life situations.

Measures of Impairment

The physiologic measures reflect various dimensions of the respiratory impairment associate with the dysarthria, such as:

- Ability to maintain targeted levels of subglottal air pressure (in cm $H_2O$) in either speech or non-speech activities
- Forced vital capacity
- Chest wall kinematics
- Spirometry

Perceptual measures may involve both speech and nonspeech tasks and include the following examples:

- Sustained phonation time
- Changes in intensity and duration of sustained phonation
- Number of syllables per breath
- Sound pressure level during speech
- Perceptual judgments of loudness
- Speech intensity with and without abdominal binder
- Perceived ease of onset of phonation

Measure of Activity/Participation

Measures of the activity of speaking typically include the overall measures of the adequacy of speech such as the following:

- Speech intelligibility
- Speaking rate
- Ratings of the naturalness of speech

- Speaker ratings of fatigue associated with speaking

Measure of participation would include those instruments that rate performance of an activity in a life situation. Although some questionnaires or surveys exist (Hustad, 1999; Yorkston, Bombardier, & Hammen, 1994), they generally have not been used in studies of treatment efficacy.

Improved coordination/control

When the focus of treatment is respiratory/phonatory coordination and control, measures reflecting impairment in physiologic function are used. The following are some measures of impairment that have been used as outcomes measures:

- Abdominal excursion and % abdominal contribution
- Offset latency and phonation times
- Lung volume excursion
- Perceived ease of onset of phonation
- Phonatory flows
- Breathing pattern during speech
- Number of syllables per breath

The outcome measures reflecting Activity/Participation are similar to those described earlier in the discussion of intervention focused on improving respiratory support.

Improve phonatory function

When the focus of treatment is improved phonatory function, measures reflecting impairment in physiologic function and activity/participation can be used.

Measures of Impairment

Physiologic measures of phonatory impairment include:

- Aerodynamic and videostroboscobic measures
- Electroglottographic data
- Physiologic measures of subglottal pressure, laryngeal resistance, phonatory flow
- Jitter and shimmer

Acoustic measures include:

- Acoustic measures of intensity, intensity range and mean intensity
- Duration of sustained phonation
- Maximum fundamental frequency, range of fundamental frequency
- Utterance and pause duration during reading and conversational monologue
- Acoustic measures of sound pressure level
- Percent voiced phonation

Perceptual measures include:

- S/Z ratio
- Perceptual ratings of loudness
- 
- Perceptual judgments of phonation, vocal tone, appropriateness of pitch, loudness
- Family and subject self-ratings of loudness, monotonicity, hoarseness, or breathiness
- Number of syllables per breath and per minute

Measures of Activity/Participation

The following measures of overall adequacy of speaking and success of speaking in life situations have also been reported:

- Perceptual judgments of intelligibility using the *Dysarthria Profile, Assessment of Intelligibility of Dysarthric Speech,* and direct magnitude estimation
- Severity of dysarthria as measured by the *Frenchay Dysarthria Assessment*
- Self evaluation of oral communication
- Perceptual judgments of speech naturalness
- Questionnaires sent to relatives and friends of patient addressing intelligibility at home, emotions relating to patient's attempts to communicate, etc.
- Probes of intensity outside of clinic (using portable intensity feedback device and recorder)
- *Beck Depression Inventory*
- *Sickness Impact Profile*
- Questionnaires on communication strategies and communicative effectiveness (Yorkston et al., 1992)

Consider AAC (Figure 5Q)

If a speaker remains unable to communicate satisfactorily following intervention, augmentative or alternative modes of communication should be pursued. The particular AAC systems chosen will depend on multiple factors, including the motor, sensory, cognitive and linguistic abilities of the patient. A future module of the Practice Guidelines for Dysarthria Management will address speech supplementation issues. Please refer to texts such as Beukelman and Mirenda (1998) for a more comprehensive overview of the management of people with dysarthria using augmentative and alternative forms of communication.

Some AAC devices specific to respiratory/phonatory dysfunction are outlined by Duffy (1995) and include:

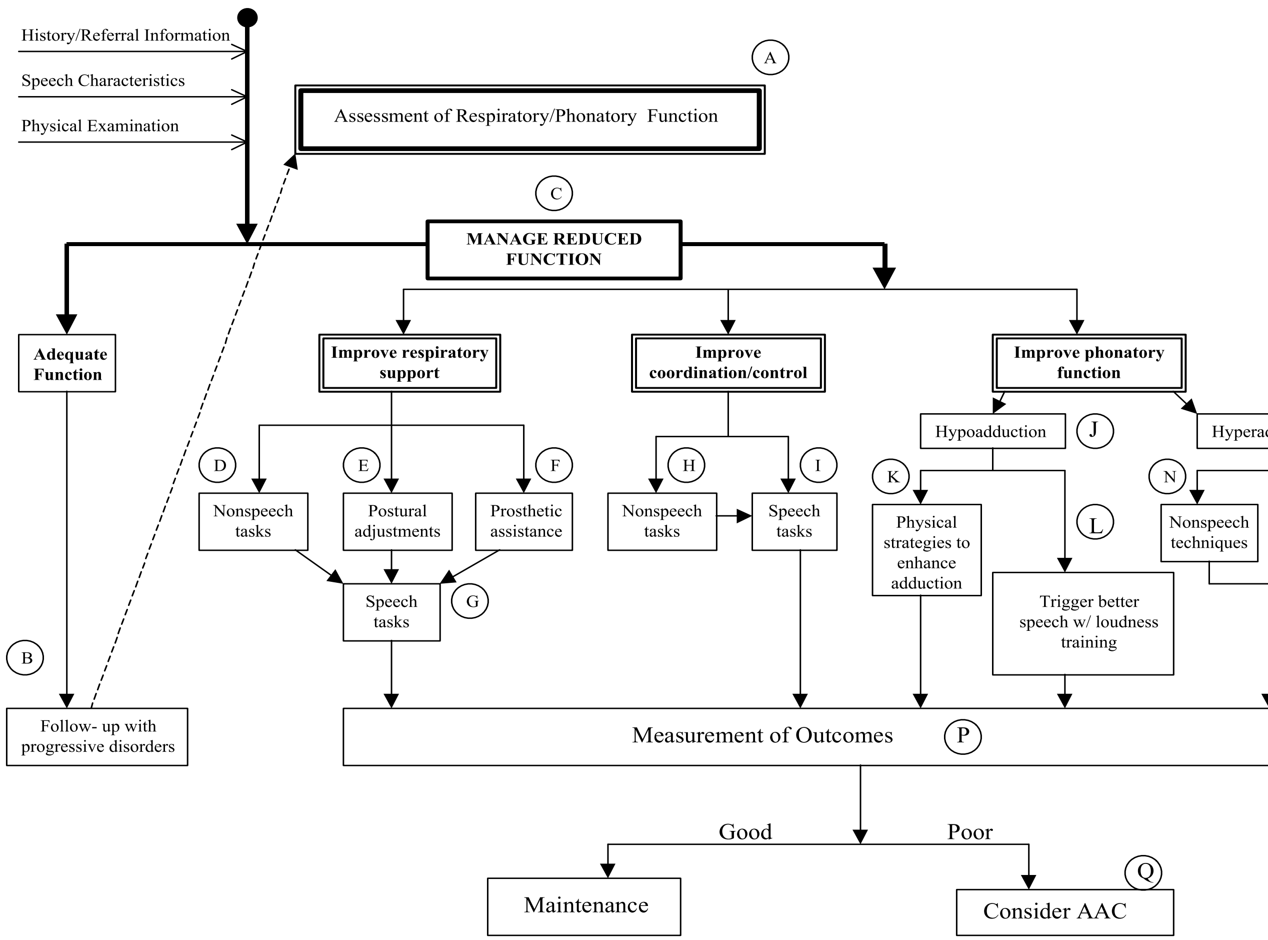
- Vocal intensity controllers
- Portable amplification system
- Electrolarynges (artificial larynx)

A vocal intensity controller informs the speaker when their loudness has fallen below a certain criterion level. It is most appropriate for patients with adequate speaking rate and articulation. Rubow and Swift (1985) used a portable biofeedback device for a patient with breathiness, reduced loudness and mild articulatory imprecision from Parkinson disease. The patient demonstrated improvement perceptually and acoustically, both within and outside of treatment sessions.

Portable amplification systems can be used for patients with decreased loudness but adequate articulation. Simpson, Till and Goff (1988) (Simpson et al., 1988) demonstrated success with a voice amplifier for a patient with severe dysarthria from basilar artery infarct. The amplifier was employed following negligible improvement from respiratory prosthetic and biofeedback treatments. Cariski and Rosenbek (1999) investigated the effect of an amplification system on two patients who evidenced articulatory imprecision. The authors report that the Speech Enhancer (x) is designed to both amplify and clarify dysarthric speech. Treatment with the Speech Enhancer, coupled with behavioral therapy to increase phonatory effort, substantially improved intelligibility in two patients with severe hypokinetic dysarthria. Both patients had failed with traditional voice amplification and behavioral therapy in the past.

An electrolarynx may be an option for patients who are aphonic or severely breathy, but have good articulation skills. No studies examining the effectiveness of this method have been conducted.

Figure 5. A flowchart of clinical decision-making for respiratory-phonatory dysfunction in dysarthria.



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