Evidence-Based Systematic Review: Effects of Nonspeech Oral Motor Exercises on Speech

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Purpose: The purpose of this systematic review was to examine the current evidence for the use of oral motor exercises (OMEs) on speech (i.e., speech physiology, speech production, and functional speech outcomes) as a means of supporting further research and clinicians’ use of evidence-based practice.

Method: The peer-reviewed literature from 1960 to 2007 was searched for articles examining the use of OMEs to affect speech physiology, production, or functional outcomes (i.e., intelligibility). Articles that met selection criteria were appraised by 2 reviewers and vetted by a 3rd for methodological quality, then characterized as efficacy or exploratory studies.

Results: Fifteen studies met inclusion criteria; of these, 8 included data relevant to the effects of OMEs on speech physiology, 8 on speech production, and 8 on functional speech outcomes. Considerable variation was noted in the participants, interventions, and treatment schedules. The critical appraisals identified significant weaknesses in almost all studies.

Conclusions: Insufficient evidence to support or refute the use of OMEs to produce effects on speech was found in the research literature. Discussion is largely confined to a consideration of the need for more well-designed studies using well-described participant groups and alternative bases for evidence-based practice.

Key Words: oral motor treatment, evidence-based systematic review, speech disorders
Despite the popularity of OMEs, however, their probable value has been seriously questioned (e.g., Lof & Watson, 2008). Criticisms have typically cited a lack of supportive evidence and problems with identified rationales (Clark, in press; Forrest, 2002). In particular, rationales have been questioned in terms of their relevance for a particular population (e.g., the use of strengthening exercises if strength is not an underlying problem) and the likelihood that methods used to implement them will be effective (e.g., the use of strengthening exercises that seem unlikely to tax, and therefore to strengthen, targeted muscles). Nonetheless, a number of critics also suggest that given their widespread use and the potential value of selected OMEs for specific purposes, vigorous investigation of OMEs is warranted.

Because of the absence of systematic reviews on the effectiveness of OMEs (at the conception of this series), the documented interest by clinicians in OMEs (Mullen, 2005), and controversies about their use with a variety of populations (e.g., Hodge et al., 2005; Lof & Watson, 2008), a systematic review on this topic was considered timely. Systematic reviews are one of the highest forms of evidence for answering clinical questions (Dollaghan, 2007; McCauley & Hargrove, 2004). EBSRs represent an emerging research methodology designed to reduce bias and promote transparency in the synthesis of evidence for research and clinical purposes (Guyatt & Rennie, 2002), such as is needed for OMEs. As part of EBSR methodology, multiple reviewers follow thoroughly prescribed procedures that include operationally defined criteria and the examination of inter-reviewer agreement to identify and assess the scientific literature; their results offer the current best available evidence on a particular intervention or diagnostic procedure under investigation.

Systematic reviews free individual clinicians and researchers from finding, evaluating, summarizing, and synthesizing research articles spanning numerous years and journals. Further, such reviews reduce the likelihood that these same individuals will need to contend with the inconsistencies and probable errors resulting from the informal and usually undocumented process typifying most narrative reviews (McCauley & Hargrove, 2004). Thus, while no more immune from criticism than any other research method (Ylvisaker et al., 2002), EBSRs offer clear-cut bases on which proponents can defend (and critics attack) their conclusions. Depending on the maturity of research in a clinical area, EBSRs can serve as a starting point for clinicians and researchers who are interested in obtaining a thorough, if imperfect, sense of (a) what research has been done to support decision making in a given area of clinical practice, (b) how rigorous that research has been, and (c) what further research needs to be conducted.

The purpose of this review was to examine the current state of evidence for the use of OMEs in speech treatment. OMEs were operationally defined as nonspeech activities that involve sensory stimulation to or actions of the lips, jaw, tongue, soft palate, larynx, and respiratory muscles that are intended to influence the physiological underpinnings of the oropharyngeal mechanism to improve its functions. They may include activities described as active muscle exercise, muscle stretching, passive exercise, or sensory stimulation. This EBSR is part of a series of reviews investigating the use of OMEs across all aspects of SLP treatment (i.e., speech and swallowing). This article focused solely on the impact of OMEs on speech; in particular, it focused on three clinical questions concerning outcomes commonly addressed in clinical practice:

1. What is the influence of OMEs on speech physiology (e.g., acoustic, kinematic, and articulatory placement)?
2. What is the influence of OMEs on speech production (i.e., perceptual accuracy)?
3. What is the influence of OMEs on functional speech outcomes, where functional speech outcomes were measures addressing the impact of the speech production errors on communication (i.e., intelligibility)?

For an EBSR examining the use of OMEs (specifically neuromuscular electrical stimulation) on swallowing, see Clark, Lazarus, Arvedson, Schooling, and Frymark (2009).

**Method**

A systematic search of the literature was conducted starting in December 2006 and continuing through September 2007. Studies were initially considered for the review if they were published in a peer-reviewed journal from 1960 to 2007, were written in English, and contained original data addressing one or more of the clinical questions included in this series of EBSRs. Studies that included surgical, medical, or pharmacological treatment or studies using liquid or food as part of the intervention were excluded. Additionally, studies that incorporated mixed treatments that were not controlled for within the research design (e.g., studies examining speech treatment paired with oral motor treatment without a speech treatment—only control group) were excluded because they did not allow for an examination of the influence of OME. Twenty-one electronic databases and other sources were searched using a total of 71 expanded key words related to OMEs, swallowing, and speech therapy. The following electronic databases were searched: Academic Search Premier, CINAHL, Communication & Mass Media Complete, EMBASE, ERIC, Evidence-Based Medicine Guidelines, Health Source: Nursing, HighWire Press, National Electronic Library for Health, PsycArticles, PsycINFO, PubMed, REHABDATA, Science Citation Index, ScienceDirect, Social Science Citation Index, SUMSearch, TRIP Database, and the Cochrane Database of Systematic Reviews. An electronic search of the ASHA journals and of Google Scholar as well as a manual search of references from all relevant articles were also completed.

As displayed in Figure 1, a total of 899 citations were identified as part of the broader search examining OMEs in speech and swallowing treatment. Two N-CEP reviewers (the fourth and fifth authors), blinded from one another’s results, reviewed each abstract and initially identified 346 citations as preliminarily meeting the inclusion criteria with 91% agreement. Of those, 250 were subsequently excluded by these two reviewers because they did not directly address one or more of the larger set of clinical questions or report original data. A total of 96 studies were identified for inclusion in this series of EBSRs. Of these, 15 studies...
addressed one or more of the three clinical questions related specifically to speech for final inclusion in this review.

The fourth and fifth authors, still blinded to one another’s results, assessed the 15 studies for methodological quality in the following areas: study design, assessor blinding, sampling/allocation, subject comparability/description, outcomes, significance, precision, and intention-to-treat (when applicable; Dollaghan, 2007). Each study received a point for each marker meeting the highest level of quality (see Table 1), and a final score was derived from the total number of indicators that met the highest level of quality. For studies incorporating randomized controlled trials (i.e., studies in which participants were randomly assigned to a treatment or control group), all eight quality indicators were relevant, leading to a maximum quality score of 8. For all other study designs, for which an intention-to-treat analysis was not applicable, the highest quality score was 7. An intention-to-treat analysis of a randomized controlled trial ensures that participants are analyzed according to the group to which they were initially randomly allocated, regardless of whether they dropped out, fully complied with the treatment, or crossed over and received the other treatment (ASHA, 2008). Such analyses are intended to help the study provide information about the quality of the decision to use a particular treatment prior to any treatment having occurred—the same conditions under which such decisions are made clinically (Fletcher & Fletcher, 2005).

Each critical appraisal was reviewed and vetted by at least one member of the three-member evidence panel (i.e., the first three authors) who also completed the data extraction (i.e., participant description, intervention provided, treatment schedule, etc.) for the study. Agreement between the N-CEP and panel reviewers was greater than 98%, and any discrepancies in ratings were resolved via consensus among the full author panel. Along with assessing methodological rigor, each study was also characterized as efficacy or exploratory research. To be considered efficacy research, a study had to incorporate an experimental or quasi-experimental design, be conducted on a disordered population, and examine the effects of OMEs as a treatment and not just a condition in which speech or swallowing skills were examined. The remaining studies not meeting those three criteria (i.e., studies with nonexperimental designs, studies conducted on nondisordered populations, or studies using OMEs as a condition to examine speech or swallowing abilities instead of as an intervention) were classified as exploratory research. A final synthesis of the body of scientific literature was reported based on clinical question and corresponding research category.

For efficacy studies, detailed information regarding participants, treatment characteristics, and individual scores for each quality indicator were given. For exploratory studies, a study summary and an overall quality score were reported. Effect sizes and confidence intervals were calculated for
outcome measures from efficacy studies whenever possible. Effect sizes are point estimates that indicate the importance of a finding, rather than the likelihood that the observed effect was due to chance or sampling error (which is the meaning of statistical significance). Confidence intervals provide an estimation of the precision of that point estimate. In other words, measures of effect size are designed to indicate the degree to which a null hypothesis is false, and the corresponding confidence interval provides a range in which the true value of the effect size is most likely to occur (Dollaghan, 2007). For group studies, Cohen’s $d$ was calculated from group means and standard deviations or estimated from results of analyses of variance or $t$ tests.

Although the magnitude of effect sizes was reported using Cohen’s benchmarks for small, medium, and large as 0.2, 0.5, and 0.8, respectively (Cohen, 1988), confidence intervals surrounding these effect sizes should be considered when interpreting these results.

### Results

Of the 15 studies that met the inclusion criteria, 8 addressed the effects of OMEs on speech physiology (Question 1), 8 addressed sound production (Question 2), and 5 addressed functional speech outcomes (Question 3). This total exceeds 15 because several studies addressed more than one of the clinical questions.

#### Clinical Question 1: What Is the Influence of OMEs on Speech Physiology?

Of the eight studies reporting data related to OMEs and speech physiology outcomes, five met the criteria for efficacy studies, and three met criteria for exploratory studies.

**Efficacy Studies**

Table 2 provides a detailed description of the interventions and participants reported in the efficacy studies. The five studies incorporated a wide range of participants, interventions, and treatment schedules. Christensen and Hanson (1981) examined the effectiveness of OMEs (specifically tongue thrust treatment with neuromuscular facilitation techniques) combined with articulation treatment relative to articulation treatment only in treating first graders with a severe tongue thrust. Another study (Korbmacher, Schwan, Berndsen, Bull, & Kahl-Nieke, 2004) focused on children with multiple orofacial dysfunctions and compared two different OME programs for tongue thrusting (i.e., traditional myofunctional treatment and an orofacial exercise program incorporating a training device called a “face former”). The three remaining studies (Backman, Grever-Sjolander, Holm, & Johansson, 2003; Carlstedt, Henningsson, & Dahllof, 2003; Carlstedt, Henningsson, McAllister, & Dahllof, 2001) compared the use of oral stimulating plates and OMEs (i.e., oral motor and sensory stimulation or SLP-designed physiotherapy program) with OMEs alone in young children with

### Table 1. Quality indicators.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Quality marker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study design</td>
<td>• Controlled trial&lt;br&gt;• Cohort study&lt;br&gt;• Retrospective case control or single-subject design&lt;br&gt;• Case series&lt;br&gt;• Case study</td>
</tr>
<tr>
<td>Blinding</td>
<td>• Assessors blinded&lt;br&gt;• Assessors not blinded or not stated</td>
</tr>
<tr>
<td>Sampling/allocation</td>
<td>• Random sample adequately described&lt;br&gt;• Random sample inadequately described&lt;br&gt;• Convenience sample adequately described&lt;br&gt;• Convenience sample inadequately described or hand-picked sample or not stated</td>
</tr>
<tr>
<td>Group/participant comparability</td>
<td>• Groups/participants comparable at baseline on important factors (between-subjects design) or participant(s) adequately described (within-subjects design)&lt;br&gt;• Groups/participants not comparable at baseline or comparability not reported or participant(s) not adequately described</td>
</tr>
<tr>
<td>Outcomes</td>
<td>• At least one primary outcome measure is valid and reliable.&lt;br&gt;• Validity is unknown but appears reasonable; measure is reliable.&lt;br&gt;• Invalid and/or unreliable</td>
</tr>
<tr>
<td>Significance</td>
<td>• $P$ value reported or calculable&lt;br&gt;• $P$ value neither reported nor calculable</td>
</tr>
<tr>
<td>Precision</td>
<td>• Effect size and confidence interval reported or calculable&lt;br&gt;• Effect size or confidence interval, but not both, reported or calculable&lt;br&gt;• Neither effect size nor confidence interval reported or calculable</td>
</tr>
<tr>
<td>Intention-to-treat (controlled trials only)</td>
<td>• Analyzed by intention-to-treat&lt;br&gt;• Not analyzed by intention-to-treat or not stated</td>
</tr>
</tbody>
</table>

Note. Boldface indicates highest level of quality marker.
<table>
<thead>
<tr>
<th>Citation</th>
<th>N</th>
<th>Age</th>
<th>Gender</th>
<th>Medical and/or SLP diagnosis as reported in article</th>
<th>Intervention</th>
<th>Treatment schedule and amount</th>
<th>Outcome measure(s)</th>
<th>Significance</th>
<th>Effect size (95% confidence interval)</th>
<th>Quality marker score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backman et al. (2003)</td>
<td>106</td>
<td>15–22 months; M = 18.3 months</td>
<td>60 M, 46 F</td>
<td>Down syndrome</td>
<td>Intervention group—oral stimulating plates and oral motor sensory stimulation</td>
<td>Plates worn 2–3 times per day for periods of 5–30 min</td>
<td>SLP perception of motor prerequisites for articulation.</td>
<td>NR</td>
<td>NR</td>
<td>1/8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Control group 1 (age-matched nondisordered)—no treatment</td>
<td>Control group 2—oral motor and sensory stimulation</td>
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<tr>
<td>Carlstedt et al. (2001)</td>
<td>20</td>
<td>3–33 months</td>
<td>12 M, 8 F</td>
<td>Down syndrome</td>
<td>Intervention group—oral stimulating plate therapy plus physiotherapy program designed by SLP</td>
<td>Plates worn for 1 hr 2–3 times per day for a minimum of 4 years (range = 49–58 months)</td>
<td>Clinical examination of lip rounding during speech</td>
<td>p &lt; .01</td>
<td>NR</td>
<td>5/8</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Control group—physiotherapy program designed by SLP</td>
<td>Control group—physiotherapy program designed by SLP</td>
<td></td>
<td>Video registration of percentage of tongue protrusion during speech</td>
<td>NS</td>
<td>0.25 (~0.65–1.12)</td>
<td></td>
</tr>
<tr>
<td>Carlstedt et al. (2003)</td>
<td>20</td>
<td>3–33 months</td>
<td>12 M, 8 F</td>
<td>Down syndrome</td>
<td>Intervention group—oral stimulating plate therapy plus physiotherapy program designed by SLP</td>
<td>Plates worn for 1 hr 2–3 times per day for a minimum of 4 years (range = 49–58 months)</td>
<td>Clinical examination of articulatory placement</td>
<td>NS</td>
<td>NR</td>
<td>2/8</td>
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<tr>
<td></td>
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<td></td>
<td>Control group—physiotherapy program designed by SLP</td>
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<th>Effect size (95% confidence interval)</th>
<th>Quality marker score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Christensen and Hanson (1981)</td>
<td>10</td>
<td>5;8 (years; months)–6;9; M = 6;2</td>
<td>6 M, 4 F</td>
<td>Severe anterior tongue thrust and acoustically severe frontal lisp</td>
<td>Intervention group—tongue thrust treatment incorporating neuromuscular facilitation techniques for first 6 weeks followed by alternating sessions of tongue thrust and articulation treatment for the next 8 weeks. Control group—conventional articulation treatment</td>
<td>All participants (both intervention and control group) received a total of 22 individual ½-hr treatment sessions. Therapy was provided once a week for 6 weeks followed by twice a week for 8 weeks.</td>
<td>Tongue tip placement on lingua-alveolar sounds</td>
<td>NS</td>
<td>0.34 (–0.94–1.56)</td>
<td>6/8</td>
</tr>
<tr>
<td>Korbmacher et al. (2004)</td>
<td>45</td>
<td>3;11–16;11; M = 8;4</td>
<td>32 M, 13 F</td>
<td>Multiple untreated orofacial dysfunctions</td>
<td>Intervention group—face former therapy, which consisted of a series of lip and tongue exercises with a flexible silicone training device. Control group—conventional myofunctional therapy</td>
<td>Both groups were followed for 6 months. Intervention group performed 20 repetitions of the exercises 3 times per day. After 3 weeks, the training device was worn overnight. Control group—not reported</td>
<td>SLP examination of movement patterns during production of alveolar sounds</td>
<td>NS</td>
<td>NR</td>
<td>4/8</td>
</tr>
</tbody>
</table>

Note. SLP = speech-language pathologist; NR = not reported or calculable; NS = not significant.
Down syndrome. Amount, duration, and intensity of treatment varied greatly among studies. Duration of treatment ranged from 14 weeks to 58 months across studies, and frequency of intervention ranged from once a week to three times per day. For all but one of the studies (Christensen & Hanson, 1981), the treatment schedules for the control groups were not stated.

Table 3 summarizes the quality marker ratings for each study. All five studies were controlled trials, and most (four) reported data in a manner in which statistical significance was calculable. However, the studies achieved poor quality marker ratings for the following areas: sampling/allocation, blinding, and intention-to-treat. Specifically, description of the comparability between groups was adequately reported in only one study (Korbmacher et al., 2004), and analysis of data by an intention-to-treat protocol was noted in only one study (Christensen & Hanson, 1981). In addition, the blinding of the assessors to the treatment condition was indicated in only two studies (Christensen & Hanson; Korbmacher et al.).

Two of the studies provided sufficient information and used measures of speech physiology for which treatment effect sizes were calculable. In Christensen and Hanson (1981), OMEs plus articulation treatment had a small positive effect ($d = 0.34$) over articulation treatment alone in tongue tip placement on lingua-alveolar sounds. Carlstedt et al. (2001) also reported a small positive effect ($d = 0.25$) of oral stimulating plates in addition to OMEs over OMEs alone for one dependent variable—percentage of tongue protrusion during speech. The OME group showed significant improvement on another dependent variable, clinical examination of lip rounding during speech; however, an effect size was not reported or calculable. Three other studies provided further evidence on the effects of OMEs, although effect sizes were not reported or calculable. Two studies (Carlstedt et al., 2003; Korbmacher et al., 2004) reported no significant changes in speech physiology outcomes following OMEs, and one study (Backman et al., 2003) did not provide sufficient data to analyze the findings statistically.

**Exploratory Studies**

The three exploratory studies examined the use of orofacial myofunctional therapy and orofacial physiotherapy, primarily in participants with lip and tongue dyskinesias, and some with cerebral palsy or dysarthria secondary to right hemisphere brain damage (see Appendix A). However, they were not considered efficacy studies because none used an experimental or quasi-experimental design. Two studies reported no changes (Ray, 2001, 2002), and one study reported positive changes (Daglio, Schwitzer, Wuthrich, & Kallivroussis, 1993) in speech physiology subsequent to OME. None of the studies, however, used experimental controls, and methodological limitations precluded the calculation of effect sizes.

**Clinical Question 2: What Is the Influence of OMEs on Sound Production?**

Four efficacy studies and four exploratory studies investigated the effects of OMEs on sound production as assessed through both formal and informal measures.

**Efficacy Studies**

As noted in Table 4, the four efficacy studies included in this review addressed a variety of populations and interventions.

Two studies (Baskervill, 1976; Christensen & Hanson, 1981) compared the effectiveness of articulation treatment plus neuromuscular facilitation or myofunctional treatment to articulation treatment alone in school-age children exhibiting sibilant distortion and tongue thrust. The third study (Carlstedt et al., 2003) evaluated the use of oral stimulating plates combined with OMEs compared to OMEs only in young children with Down syndrome. The fourth study (Logemann, Pauloski, Rademaker, & Colangelo, 1997) examined the effects of range of motion and coordination exercises of the lips, tongue, jaw, and larynx in individuals with head and neck cancer.

Table 5 summarizes the methodological quality ratings for each of the four studies. Three of the four studies were controlled trials; therefore, all eight quality markers were applicable. Logemann et al. (1997) was considered a cohort study, so the eighth marker (intention-to-treat analysis) was not relevant. Most of the studies (three) had valid and reliable outcome measures, and reported or supplied sufficient data to calculate statistical significance. One study (Christensen & Hanson, 1981) reported blinding of the assessors to the treatment condition and data analysis by an intention-to-treat standard. Neither random allocation of participants to groups nor adequate description of randomization procedures or methods taken to ensure participant comparability between groups was reported in any of the included studies.

Cohen’s $d$ values were calculated for two studies (Christensen & Hanson, 1981; Logemann et al., 1997). The three effect sizes ranged from $-0.69$ to $0.19$. The two effect sizes calculated from Christensen and Hanson (1981) both favored articulation treatment alone over articulation treatment plus OME. A small effect ($d = -0.44$) was noted on the total number of /s/ and /z/ errors, and a medium effect ($d = -0.69$) on Goldman Fristoe Test of Articulation scores (Goldman & Fristoe, 1972). Logemann et al. reported a negligible effect (0.19) for the use of OMEs (i.e., range of motion exercises) for improving speech sound production as measured by the Fisher–Logemann Test of Articulation Competence (Fisher & Logemann, 1971). Two other efficacy studies also addressed this question, but effect sizes were not calculable. One study (Carlstedt et al., 2003) reported no significant improvements in speech sound production following OMEs, and the other study (Baskervill, 1976) did not report or supply adequate data to calculate statistical significance for differences on the McDonald Deep Test of Articulation (McDonald, 1964).

**Exploratory Studies**

Four exploratory studies addressed this clinical question and examined the use of various OMEs in school-age children (see Appendix B). Two studies (Guisti Braislin & Cascella, 2005; Powers & Starr, 1974) reported no significant changes in speech sound production following OMEs, and two studies (Fischer-Brandies, Avalle, & Limbrock, 1987; Ray, 2003) did not provide sufficient data to analyze the findings statistically.

**Clinical Question 3: What Is the Influence of OMEs on Functional Speech Outcomes?**

Six studies related to OMEs and functional speech outcomes (i.e., intelligibility) were identified. Two of the studies
<table>
<thead>
<tr>
<th>Citation</th>
<th>Study design</th>
<th>Blinding</th>
<th>Allocation</th>
<th>Subjects</th>
<th>Outcomes</th>
<th>Significance</th>
<th>Precision</th>
<th>Intention-to-treat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backman et al. (2003)</td>
<td>Controlled trial</td>
<td>Not stated</td>
<td>Convenience sample/ hand-picked sample</td>
<td>Comparability not reported</td>
<td>Invalid and/or unreliable</td>
<td>P value neither reported nor calculable</td>
<td>Neither effect size nor confidence interval reported or calculable</td>
<td>Not stated</td>
</tr>
<tr>
<td>Carlstedt et al. (2001)</td>
<td>Controlled trial</td>
<td>Assessors not blinded</td>
<td>Random sample adequately described</td>
<td>Comparability not reported</td>
<td>At least one primary outcome measure is valid and reliable</td>
<td>P value reported or calculable</td>
<td>Effect size and confidence interval reported or calculable</td>
<td>Not stated</td>
</tr>
<tr>
<td>Carlstedt et al. (2003)</td>
<td>Controlled trial</td>
<td>Assessors not blinded</td>
<td>Random sample inadequately described</td>
<td>Comparability not reported</td>
<td>Validity unknown but appears reasonable; reliable</td>
<td>P value reported or calculable</td>
<td>Neither effect size nor confidence interval reported or calculable</td>
<td>Not stated</td>
</tr>
<tr>
<td>Christensen and Hanson (1981)</td>
<td>Controlled trial</td>
<td>Assessors blinded</td>
<td>Random sample inadequately described</td>
<td>Comparability not reported</td>
<td>At least one primary outcome measure is valid and reliable</td>
<td>P value reported or calculable</td>
<td>Effect size and confidence interval reported or calculable</td>
<td>Analyzed by intention-to-treat</td>
</tr>
<tr>
<td>Korbacher et al. (2004)</td>
<td>Controlled trial</td>
<td>Assessors blinded</td>
<td>Random sample inadequately described</td>
<td>Groups comparable at baseline on important factors (between-subjects design)</td>
<td>Invalid and/or unreliable</td>
<td>P value reported or calculable</td>
<td>Neither effect size nor confidence interval reported or calculable</td>
<td>Not analyzed by intention-to-treat</td>
</tr>
</tbody>
</table>

Note. Boldface indicates highest level of quality in each category.
<table>
<thead>
<tr>
<th>Citation</th>
<th>N</th>
<th>Age</th>
<th>Gender</th>
<th>Medical and/or SLP diagnosis as reported in article</th>
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<th>Significance</th>
<th>Effect size (95% confidence interval)</th>
<th>Quality marker score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baskervill (1976)</td>
<td>5</td>
<td>8–10 years</td>
<td>4 M, 1 F</td>
<td>Reverse swallowing pattern and sibilant distortions</td>
<td>Intervention group—Speech Improvement Program (SIS), an audio-taped articulation program focusing on auditory discrimination production and stabilization plus myofunctional treatment targeting strengthening of orofacial musculature and tongue as well as tongue tip placement during swallowing Control group—SIS only</td>
<td>16 sessions were scheduled for 30–45 min, 3 times per week.</td>
<td>McDonald Deep Test of Articulation (McDonald, 1964)</td>
<td>NR</td>
<td>NR</td>
<td>2/8</td>
</tr>
<tr>
<td>Carlstedt et al.</td>
<td>20</td>
<td>3–33 months</td>
<td>12 M, 8 F</td>
<td>Down syndrome</td>
<td>Intervention group—oral stimulation plate therapy plus physiotherapy program designed by SLP Control group—physiotherapy program designed by SLP</td>
<td>Plates were worn for 1 hr 2–3 times per day for a minimum of 4 years (range = 48–58 months). Control group—not reported</td>
<td>Clinician judgment of consonant production</td>
<td>NS</td>
<td>NR</td>
<td>2/8</td>
</tr>
<tr>
<td>Christensen and Hanson (1981)</td>
<td>10</td>
<td>5.8–6.9: M= 6.2</td>
<td>6 M, 4 F</td>
<td>Severe anterior tongue thrust and acoustically severe frontal lip</td>
<td>Intervention group—tongue thrust treatment incorporating neuromuscular facilitation techniques for first 6 weeks followed by alternating sessions of tongue thrust and articulation treatment for the next 8 weeks. Control group—traditional articulation treatment</td>
<td>All participants (both intervention and control group) received a total of 22 individual 1/2-hr treatment sessions. Therapy was provided once a week for 6 weeks followed by twice a week for 8 weeks.</td>
<td>Total number of /s/ and /z/ errors Goldman Fristoe Test of Articulation (Goldman &amp; Fristoe, 1972)</td>
<td>NS</td>
<td>-0.44 (~1.65–0.86)</td>
<td>-0.69 (~1.9–0.64)</td>
</tr>
<tr>
<td>Logemann et al. (1997)</td>
<td>102</td>
<td>Not reported</td>
<td>Not reported</td>
<td>Surgically treated oral and oropharyngeal cancer</td>
<td>Instruction in range of motion and/or coordination exercises of the lips, tongue, jaw, and larynx. Participants were instructed to perform the group of exercises for 5–10 min, 10 times per day.</td>
<td>Fishman–Logemann Test of Articulation Competence (Fishman &amp; Logemann, 1971)</td>
<td>NS</td>
<td>0.19 (~0.23–0.6)</td>
<td>3/7</td>
<td></td>
</tr>
</tbody>
</table>
TABLE 5. Appraisal summary of sound production efficacy studies (Question 2).

<table>
<thead>
<tr>
<th>Citation</th>
<th>Study design</th>
<th>Blinding</th>
<th>Allocation</th>
<th>Subjects</th>
<th>Outcomes</th>
<th>Significance</th>
<th>Precision</th>
<th>Intention-to-treat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baskerville (1976)</td>
<td>Controlled</td>
<td>Not stated</td>
<td>Convenience sample/hand-picked sample</td>
<td>Comparability not reported</td>
<td>At least one primary outcome measure is valid and reliable</td>
<td>P value neither reported nor calculable</td>
<td>Neither effect size nor confidence interval reported or calculable</td>
<td>Not analyzed by intention-to-treat</td>
</tr>
<tr>
<td>Carlstedt et al. (2003)</td>
<td>Controlled</td>
<td>Assessors not blinded</td>
<td>Random sample inadequately described</td>
<td>Comparability not reported</td>
<td>Validity unknown but appears reasonable; reliable</td>
<td>P value reported or calculable</td>
<td>Not analyzed by intention-to-treat</td>
<td></td>
</tr>
<tr>
<td>Christensen and Hanson (1981)</td>
<td>Controlled</td>
<td>Assessors blinded</td>
<td>Random sample inadequately described</td>
<td>Comparability not reported</td>
<td>At least one primary outcome measure is valid and reliable</td>
<td>P value reported or calculable</td>
<td>Not analyzed by intention-to-treat</td>
<td></td>
</tr>
<tr>
<td>Logemann et al. (1997)</td>
<td>Cohort study</td>
<td>Not stated</td>
<td>Convenience sample/hand-picked sample</td>
<td>Comparability not reported</td>
<td>At least one primary outcome measure is valid and reliable</td>
<td>P value reported or calculable</td>
<td>Analyzed by intention-to-treat</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

Note. Boldface indicates highest level of quality in each category.
met the criteria for efficacy research, and four met those for exploratory research.

**Efficacy Studies**

Of the two efficacy studies addressing this clinical question (see Table 6), one was a controlled trial examining the effects of two different OMEs (OMEs with oral stimulating plate compared with OMEs alone) in children with Down syndrome (Carlstedt et al., 2003); the other was a cohort study that described the changes associated with OMEs in participants with head and neck cancer (Logemann et al., 1997). The methodological quality ratings for each study are reported in Table 7. Both studies reported or supplied sufficient data to calculate statistical significance and effect sizes. Neither study provided an adequate description of the comparability between groups, used outcome measures with known or reported validity and reliability, or allocated participants with well-described randomization procedures. One study (Logemann et al., 1997) reported blinding of the assessors to the treatment condition.

Three effect sizes were calculable from these two studies and ranged from –0.56 to 0.4. The two effect sizes calculated from Carlstedt et al. (2003) favored OMEs only over OMEs plus oral stimulating plates. A medium effect \( d = -0.56 \) was noted on parent perception of participants’ intelligibility to family members and a negligible effect \( d = -0.02 \) for parent perception of participants’ intelligibility to strangers. The small effect size \( d = 0.4 \) calculated from Logemann et al. (1997) described the positive change in intelligibility of conversational speech for participants performing range of motion exercises versus those who did not.

**Exploratory Studies**

Three exploratory studies contributed data to address this clinical question (see Appendix C). The studies examined the use of OMEs in participants with dysarthria secondary to various etiologies including traumatic brain injury, stroke, and cerebral palsy. These studies only used pre- and posttest designs. No significant changes were noted in measures of intelligibility of sentences or conversations (Ray, 2002). Two studies (Ray, 2001, 2002) reported significant positive changes in single word intelligibility, and one study (Jones et al., 2006) did not provide sufficient data to analyze the findings.

**Effect of Study Quality on Results**

Results from included studies were analyzed to determine whether variations in study quality were associated with variations in effect size. However, because there were only minimal discrepancies among the included studies in quality or effect sizes, no conclusions were possible.

**Discussion**

Few treatment strategies in speech-language pathology have generated as much interest and controversy as non-speech OMEs directed at speech improvement (Powell, 2008; Watson & Lof, 2008). This systematic review does little to resolve the controversies surrounding the use of OMEs. The conclusion that must be drawn from this review is that the existing research literature provides insufficient evidence to support or refute the use of non-speech OMEs.

The difficulty of examining OMEs and speech production is multifaceted. First, very few articles have been published examining the efficacy of non-speech oral motor activities toward improving speech production. Moreover, many of the efficacy articles included in this EBSR did not compare OMEs with more traditional treatment approaches. Instead, these articles compared one OME intervention with a different OME intervention (as defined by this EBSR). These types of studies make it difficult to ascertain not only the absolute efficacy of OMEs but also their relative efficacy compared to existing alternatives. Furthermore, many of the articles that do exist could not be included in this review because they did not address the effectiveness of OMEs alone and instead targeted the use of OMEs in combination with other treatment approaches. While this combination approach is often used clinically (Joffe & Pring, 2008; Lof & Watson, 2008), it is not possible to determine the true impact and added value of an intervention if it is not examined separately or controlled for within a research design.

An additional important study was a literature review of non-speech oral motor treatments (Lass & Pannbacker, 2008) that was published as this article was being finalized. Although that article addressed a similar, although not identical, topic to the one addressed here, its methods differed in numerous respects from the present one. These differences included its treatment of both articulation and voice as “speech” outcomes, its inclusion of presentations and non-peer-reviewed articles as possible sources of evidence, its acceptance of studies incorporating mixed treatments, and its use of different appraisal methods. Additionally, the overlap between this review and Lass and Pannbacker’s results is small. Of the 15 studies included in Lass and Pannbacker’s article, only 3 are common to this EBSR. These differences prevent a detailed comparison of the results of that article and those reported here. In general, however, Lass and Pannbacker’s conclusions are similar in that they cite a lack of sufficient evidence supporting the use of OMEs. However, they also interpreted their findings as supporting the conclusion that OMEs “should be excluded from use as a mainstream treatment until there are further data” (p. 408), a broad conclusion we could not reach based on the data presented here.

Other articles addressing the effects of OMEs were excluded from this analysis. For example, several narrative reviews (e.g., Clark, 2003; Marshalla, 2008) were not included because they provided a summary of various OMEs and techniques but did not address the efficacy of any particular approach. Other articles were excluded from this EBSR because they were not published in the peer-reviewed literature. Limiting articles to those appearing in journals that incorporate independent scrutiny as part of their publication process is a reasonable step to ensure that some initial vetting of the research has taken place, but even doing this has shortcomings. Despite being published in the peer-reviewed literature, many of the included articles exhibited methodological weaknesses, specifically inadequate description of protocols, interventions, and participants, as well as lack of blinding. Adequate and thorough descriptions of treatment protocols and interventions are necessary to allow for replication by researchers and clinicians. Additionally, given that an important aspect of reviewing the existing
### TABLE 6. Participant and treatment characteristics—functional speech outcomes efficacy studies (Question 3).

<table>
<thead>
<tr>
<th>Citation</th>
<th>N</th>
<th>Age</th>
<th>Gender</th>
<th>Medical and/or SLP diagnosis as reported in article</th>
<th>Intervention</th>
<th>Treatment schedule and amount</th>
<th>Outcome measure(s)</th>
<th>Significance</th>
<th>Effect size (95% confidence interval)</th>
<th>Quality marker score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carlstedt et al. (2003)</td>
<td>20</td>
<td>3–33 months</td>
<td>12 M, 8 F</td>
<td>Down syndrome</td>
<td>Intervention group—oral stimulating plate therapy plus physiotherapy program designed by SLP. Control group—physiotherapy program designed by SLP.</td>
<td>Plates worn for 1 hr 2–3 times per day for a minimum of 4 years (range = 49–58 months). Control group— not reported</td>
<td>Parent perception of intelligibility to family. Parent perception of intelligibility to strangers</td>
<td>NS</td>
<td>−0.56 (−1.43–0.36)</td>
<td>3/8</td>
</tr>
<tr>
<td>Logemann et al. (1997)</td>
<td>102</td>
<td>NR</td>
<td>NR</td>
<td>Surgically treated oral and oropharyngeal cancer</td>
<td>Instruction in range of motion and/or coordination exercises of the lips, tongue, jaw, and larynx.</td>
<td>Participants were instructed to perform the group of exercises for 5–10 min, 10 times per day.</td>
<td>Percentage intelligibility of conversational speech</td>
<td>NS</td>
<td>0.4 (−0.05–0.84)</td>
<td>3/7</td>
</tr>
</tbody>
</table>

### TABLE 7. Appraisal summary of functional speech outcomes efficacy studies (Question 3).

<table>
<thead>
<tr>
<th>Citation</th>
<th>Study design</th>
<th>Blinding</th>
<th>Allocation</th>
<th>Subjects</th>
<th>Outcomes</th>
<th>Significance</th>
<th>Precision</th>
<th>Intention-to-treat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carlstedt et al. (2003)</td>
<td>Controlled trial</td>
<td>Assessors not blinded</td>
<td>Random sample inadequately described</td>
<td>Comparability not reported</td>
<td>Validity unknown but appears reasonable; reliable</td>
<td>P value reported or calculable</td>
<td>Effect size and confidence interval reported or calculable</td>
<td>Not analyzed by intention-to-treat</td>
</tr>
<tr>
<td>Logemann et al. (1997)</td>
<td>Cohort study</td>
<td>Assessors blinded</td>
<td>Convenience sample/ hand-picked sample</td>
<td>Comparability not reported</td>
<td>Validity unknown but appears reasonable; reliable</td>
<td>P value reported or calculable</td>
<td>Effect size and confidence interval reported or calculable</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

**Note.** Boldface indicates highest level of quality in each category.
A final problem in interpreting the results of this systematic review is that even within the small corpus of studies that do exist, there is a great deal of variability among the studies in the populations, types of OME, and outcomes investigated. For example, the participants included in this EBSR ranged from infants to elderly adults who exhibited a wide variety of medical diagnoses and communication disorders, including mild articulation disorder, Down syndrome, cerebral palsy, stroke, cleft palate, traumatic brain injury, tongue thrust, and oral or oropharyngeal cancer. Moreover, the types of OMEs used in these studies were equally diverse. Given the breadth of the definition of OMEs used for this EBSR, many types of OMEs were examined and included such different interventions as oral stimulating plates, myofunctional therapy, range of motion exercises, strengthening exercises, sensory stimulation, and blowing/sucking exercises. Attempting to generalize the findings of such a disparate group of studies for clinical decision making is not only problematic but ill-advised.

As Sackett, Rosenberg, Gray, Haynes, and Richardson (1996) note, evidence-based practice entails explicit use of the current best evidence from systematic research when making decisions about treatment. Another principle of evidence-based practice is the integration of individual clinical experience with that best research evidence. On the surface, that may seem to give clinicians permission to rely on prevailing and commonly used treatment. However, Sackett and colleagues also note that “it is when asking questions about therapy that we should try to avoid the nonexperimental approaches, since these routinely lead to false positive conclusions about efficacy” (p. 72). Therefore, relying on clinical experience alone and prevailing popular techniques may not be a wise way to select a specific treatment approach.

Despite the shortcomings of the evidence base for information about the value of OMEs, there are still a number of strategies to help clinicians in making the best clinical decisions regarding treatments designed to influence speech. These include implementing efficacious treatments—for populations and problems for which these have been identified, understanding the theoretical frameworks and evidence for relevant areas of basic research (e.g., speech physiology or motor learning), and examining untested treatment approaches under controlled conditions.

Probably the best option available is for clinicians to seek out alternative speech treatments whose efficacy has already been established in the literature. Especially when speech production or functional speech outcomes are the ultimate goals of intervention, treatments that directly work toward those outcomes have been proposed and studied for a large number of populations. For example, for adult patients, several systematic reviews have documented the effects of speech treatments focusing on vocal loudness, vocal effort, and pitch for improving intelligibility in individuals with dysarthria and Parkinson’s disease (Yorkston, Hakel, Beukelman, & Fager, 2007; Yorkston, Spencer, & Duffy, 2003). In the area of children’s speech sound disorders, a number of interventions have been supported for use with relatively well-defined populations—for example, minimal pairs (e.g., Ruscello, Cartwright, Haines, & Shuster, 1993) and cycles (e.g., Almost & Rosenbaum, 1998; Hodson, Nonomura, & Zappia, 1989).

A second option is presented in the form of basic research providing evidence on the underlying mechanisms by which OMEs could be expected to work—for example, evidence regarding speech physiology, speech development, and motor learning (e.g., Bunton, 2008; Clark, 2003, in press; Maas et al., 2008; Wilson, Green, Yunusova, & Moore, 2008). Discussions of evidence-based practice frequently note that because basic research does not directly address clinical questions, it is best used to help set the stage for research that does (e.g., Dollaghan, 2007). Nonetheless, when clinical evidence is missing, such research may suggest whether specific rationales or approaches are reasonable. For example, if clinicians are concerned about low tone affecting a client’s tongue or lips, knowledge of anatomy (specifically the differences in muscle spindle distribution in those structures) and physiology (in particular, the role of the muscle spindles in activating the stretch reflex) would cause them to question the use of an OME (e.g., quick stretch) intended to accomplish increases in tone through the stretch reflex (Clark, 2003). Similarly, if clinicians are concerned about the absence of /t,d/ in a child’s repertoire, knowledge of motor learning (such as the importance of targeting complex movements as a whole; Maas et al., 2008) would cause them to question the use of an OME (e.g., tongue tip elevation outside of speech) intended to improve alveolar placements in speech. Although Sackett and colleagues (1996) note that basic research conducted on a nonclinical population should not be the first place for evidence-based practice oriented clinicians to turn, such research provides a more solid base than anecdotal testimonials or expert opinions.

A third option open to clinicians seeking an efficacious treatment for their clients with speech sound disorders involves implementing reasonable and logically sound treatment approaches with clients in a controlled, experimental context. Undertaking an examination of treatment outcomes (internal evidence) for a client should always be a part of the clinical process (Baker & McLeod, 2004). However, like external evidence, internal evidence can vary in quality. For example, whereas pre- and posttesting can help a clinician gain some sense of whether change has occurred, the use of a single-subject experimental design to track progress provides more detailed information and, most importantly, helps to rule out alternative explanations for that change, such as development or recovery (Barlow, Nock, & Hersen, 2009).
If clinicians choose to incorporate interventions with no external evidence into a client’s treatment plan, the client should be informed that the treatment is exploratory (Duchan, Calculator, Sonnemeier, Diehl, & Cumley, 2001), and clinicians should carefully evaluate the effects of the treatment within a controlled treatment design.

Limitations of the Current Review

There are several limitations of this EBSR that should be considered. First, only articles published in English were included in this review. Given this, it is possible that some studies addressing the effectiveness of OMEs were not identified. Additionally, many of the identified studies were excluded because they did not address one of the targeted outcomes outlined in the clinical questions. If the clinical questions of this EBSR had been expanded to include outcomes such as increased strength or range of motion, more studies would have been available for analysis. Finally, as noted above, the wide variation across studies in terms of participants, interventions, and outcomes meant that there was no common denominator, such as a shared outcome measure, on which to evaluate OMEs or with which to conduct a comparative analysis of effect sizes.

Conclusion

This systematic review was designed to examine the current evidence for the use of nonspeech OMEs toward improving speech production. The current state of evidence is equivocal due to the lack of well-designed, experimentally controlled studies with adequate statistical power and well-described participants. Given this, clinicians must consider carefully what a particular oral motor activity is likely to accomplish and whether it addresses the impairment the client actually exhibits (based on the knowledge bases discussed above). At this time, based on theory and available evidence, the use of OMEs must be considered exploratory, and clients should be informed of this prior to initiating their use in treatment.

Future research efforts on OMEs should focus on establishing the efficacy of specific approaches through well-designed single-subject and group experimental studies that provide adequate descriptions of participants and interventions, control for the influence of variables outside of treatment, and incorporate reliable and valid outcome measures. Only by growing the research evidence base can clinicians continue to improve their ability to make sound clinical decisions.

Acknowledgments

This evidence-based review was supported by ASHA’s N-CEP. We thank the following individuals who participated in the evidence panel to review the state of the evidence on nonspeech oral motor exercise: Dr. Joan Arvedson, Dr. Heather Clark, and Dr. Cathy Lazarus. We also thank the following individuals who contributed to the preparation of this document: Beverly Wang, N-CEP Information Manager; Hillary Leech, N-CEP Research Assistant; and Rob Mullen, N-CEP Director.

References

References marked with an asterisk indicate studies included in the EBSR.


The essentials and Language, 23(1), 15–25.


Received January 21, 2009
Accepted May 8, 2009
DOI: 10.1044/1058-0360(2009/09-0006)

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### Appendix A

Summary of Speech Physiology Exploratory Studies (Question 1)

<table>
<thead>
<tr>
<th>Citation</th>
<th>N</th>
<th>Age (years)</th>
<th>Gender</th>
<th>Medical and/or SLP diagnosis as reported in article</th>
<th>Intervention</th>
<th>Treatment schedule and amount</th>
<th>Outcome measure(s)</th>
<th>Significance</th>
<th>Quality marker score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daglio et al. (1993)</td>
<td>75</td>
<td>6–22</td>
<td>22 M, 53 F</td>
<td>Frontal open bite and lip/tongue dyskinesia</td>
<td>Functional orofacial physiotherapy</td>
<td>Not stated</td>
<td>Proportion of participants with lisp based on clinical observation</td>
<td>$p &lt; .001$</td>
<td>1/7</td>
</tr>
<tr>
<td>Ray (2001)</td>
<td>16</td>
<td>7–10; $M = 8.6$</td>
<td>9 M, 7 F</td>
<td>Cerebral palsy with mild to moderate spasticity and dysarthric speech</td>
<td>Orofacial myofunctional treatment program that focused on oral sensory stimulation and exercises for lips, tongue, jaws, and cheeks</td>
<td>Participants received 25-min sessions (15 min of individual treatment and 10 min of group treatment) 5 times per week over 4 months. Additionally, parents implemented a home-based exercise program 4–5 times per day.</td>
<td>Diadochokinetic rate</td>
<td>NS</td>
<td>2/7</td>
</tr>
<tr>
<td>Ray (2002)</td>
<td>12</td>
<td>$M = 74.7$</td>
<td>Not reported</td>
<td>Single right hemisphere ischemic stroke and mild to moderate dysarthria</td>
<td>Treatment focused on oral sensory stimulation and strengthening exercises for lips, tongue, jaws, and cheeks.</td>
<td>Participants received 45-min treatment sessions twice weekly for 2 months.</td>
<td>Alternating motion rate</td>
<td>NS</td>
<td>2/7</td>
</tr>
</tbody>
</table>

Note. NS = not significant.
<table>
<thead>
<tr>
<th>Citation</th>
<th>N</th>
<th>Age</th>
<th>Gender</th>
<th>Medical and/or SLP diagnosis as reported in article</th>
<th>Intervention</th>
<th>Treatment schedule and amount</th>
<th>Outcome measure(s)</th>
<th>Significance</th>
<th>Quality marker score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fischer-Brandeis et al. (1987)</td>
<td>71</td>
<td>4–14; M = 10</td>
<td>34 M, 37 F</td>
<td>Cerebral palsy</td>
<td>Removable stimulatory plates for orofacial regulation therapy. Approximately 1/3 of the participants also received oral and facial physiotherapy.</td>
<td>Plates were worn for an average of 15 months (range = 6–36 months).</td>
<td>Observation of labial, palatal, and dental sound production</td>
<td>NR</td>
<td>0/7</td>
</tr>
<tr>
<td>Guisti Braslin and Cascella (2005)</td>
<td>4</td>
<td>6–9; M = 6;6</td>
<td>2 M, 2 F</td>
<td>Mild functional articulation disorder of unknown origin</td>
<td>Easy Does It for Articulation: An Oral-Motor Approach (Strode &amp; Chamberlain, 1997)</td>
<td>Participants received 15 1/2-hr small-group (n = 2) treatment sessions over 7 weeks.</td>
<td>Number of errors on GFTA</td>
<td>NS</td>
<td>4/7</td>
</tr>
<tr>
<td>Powers and Starr (1974)</td>
<td>4</td>
<td>8–11</td>
<td>3 M, 1 F</td>
<td>Palatal cleft repaired before age 2 and mild to moderate nasality</td>
<td>Treatment consisted of 4 sets of exercises: blowing and sucking exercises targeting velar muscle activity, and swallowing and gagging exercises focusing on pharyngeal wall muscle activity.</td>
<td>Exercises were performed 4 times per day, 5 days per week, for 6 weeks.</td>
<td>9-point equal-appearing scale ranging from mild nasality (1) to severe nasality (9), immediate posttreatment</td>
<td>NS</td>
<td>2/7</td>
</tr>
<tr>
<td>Ray (2003)</td>
<td>6</td>
<td>18–23; M = 20</td>
<td>4 M, 2 F</td>
<td>Anterior open bite with front and lateral lip; one participant described as having developmental verbal apraxia</td>
<td>Oral motor treatment focusing on tongue resting postures and lip closure. Activities included holding a tongue depressor between lips and holding the tongue tip on alveolar ridge for 15 min per day.</td>
<td>Participants received 1 45-min treatment session per week for 6 weeks plus additional home assignments.</td>
<td>Percentage of single words, sentences, and connected speech with no phonemic or phonetic errors.</td>
<td>NS</td>
<td>2/7</td>
</tr>
</tbody>
</table>

Note. NR = not reported or calculable; GFTA = Goldman Fristoe Test of Articulation (Goldman & Fristoe, 1972).
### Appendix C

**Summary of Functional Speech Outcomes Exploratory Studies (Question 3)**

<table>
<thead>
<tr>
<th>Citation</th>
<th>N</th>
<th>Age (years)</th>
<th>Gender</th>
<th>Medical and/or SLP diagnosis as reported in article</th>
<th>Intervention</th>
<th>Treatment schedule and amount</th>
<th>Outcome measure(s)</th>
<th>Significance</th>
<th>Quality marker score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jones et al. (2006)</td>
<td>1</td>
<td>26</td>
<td>1 F</td>
<td>4 years after severe traumatic brain injury with complex mixed dysarthria and Lance-Adams syndrome</td>
<td>Expiratory muscle strength training—forceful exhalation against resistance until a set level of pressure is produced</td>
<td>Participant completed 25 trials per day, 1 time per week in clinic (5 trials, followed by 5–10 min of rest) and daily at home for 6 months.</td>
<td>10 sentences, 14 words each, from the AIDS, administered posttreatment and at 3-month follow-up.</td>
<td>NR</td>
<td>2/7</td>
</tr>
<tr>
<td>Ray (2001)</td>
<td>16</td>
<td>7–10; M = 8.6</td>
<td>9 M, 7 F</td>
<td>Cerebral palsy with mild to moderate spasticity and dysarthric speech</td>
<td>Orofacial myofunctional treatment program that focused on oral sensory stimulation and exercises for lips, tongue, jaws, and cheeks</td>
<td>Participants received 25-min sessions (15 min of individual treatment and 10 min of group treatment) 5 times per week over 4 months. Additionally, parents implemented a home-based exercise program 4–5 times per day.</td>
<td>5-point intelligibility rating scale</td>
<td>p = .0023</td>
<td>4/7</td>
</tr>
<tr>
<td>Ray (2002)</td>
<td>12</td>
<td>M = 74.7</td>
<td>NR</td>
<td>Single right hemisphere ischemic stroke and mild to moderate dysarthria</td>
<td>Treatment that focused on oral sensory stimulation and strengthening exercises for lips, tongue, jaws, and cheeks</td>
<td>Participants received 45-min treatment sessions twice weekly for 2 months.</td>
<td>5-point intelligibility rating scale—single words</td>
<td>p &lt; .001</td>
<td>3/7</td>
</tr>
</tbody>
</table>

**Note.** AIDS = Assessment for Intelligibility of Dysarthric Speech (Yorkston & Beukelman, 1984).