Evidence-Based Systematic Review: Effects of Oral Sensory-Motor Treatment on Swallowing in Adults

Cathy Lazarus
NYU Langone Medical Center, New York, NY

Heather Clark
Appalachian State University, Boone, NC

Joan Arvedson
Children's Hospital of Wisconsin, Milwaukee, WI

Tracy Schooling
Tobi Frymark
National Center for Evidence-Based Practice in Communication Disorders
American Speech-Language-Hearing Association, Rockville, MD

ABSTRACT

Purpose: To systematically review and examine the state and quality of the evidence for the use of oral sensory-motor treatment (OSMT) in adults to improve swallowing physiology, pulmonary health, functional swallowing outcomes, or drooling/secretion management.

Method: Electronic literature searches were performed, with 23 studies identified as (a) pertaining to the effects of OSMT on swallowing in adult populations and (b) containing original data addressing 1 or more of the 4 areas under review. All articles were appraised for methodological rigor and classified as either efficacy or exploratory studies.

Results: Of the 23 studies identified, the majority (18/23) were classified as exploratory research. Many of the studies had significant limitations and did not meet the standards of scientific rigor needed for

treatment research. Additionally there was a large degree of heterogeneity among the studies in terms of participants, interventions, and findings.

Conclusions: Few efficacy studies have been conducted on the use of OSMT to improve swallowing in adults. Based on the results of this review, there is insufficient evidence to draw any conclusions on the utility of OSMT in dysphagia treatment. Current best evidence, client values, and clinical expertise should be incorporated into decisions about the use of treatment techniques.

Dysphagia, or difficulty swallowing, can have a devastating effect on health and quality of life, and is a growing problem in the adult population (List et al., 1999). Although the exact prevalence is unknown, epidemiological findings indicate that 22% of adults over the age of 50 (Howden, 2004) and 14% of adults over the age of 60 (Agency for Health Care Policy and Research, 1999) experience some form of dysphagia. Swallowing impairment can result in reduced ability to seal, manipulate, and propel food and liquid through the oral cavity (Logemann, 1998; McConnel, 1988) and may lead to serious consequences, such as compromised nutritional status and increased risk of aspiration pneumonia (Morris, 2006; Wilkins, Gillies, Thomas, & Wagner, 2007).

For years, speech-language pathologists (SLPs) have been integral to the management of adults with dysphagia, offering a number of treatments aimed at improving swallow function (Logemann, 1998). One of these treatments, oral sensory-motor treatment (OSMT), commonly referred to as oral motor exercises, has been commonly accepted and deeply rooted in SLPs' practice for some time. These exercises may target the lips, tongue, face, palate, or neck/larynx and are designed to improve mobility, strength, and control for swallowing. For example, lip closure range of motion and strengthening exercises are used to improve oral containment, oral pressures, and ability to manipulate and propel material from the oral cavity into the pharynx. Tongue range of motion exercises are designed to improve bolus manipulation and propulsion from the oral cavity into the pharynx, particularly in populations with head and neck cancer or neurological involvement (Daniels, Brailey, & Foundas, 1999; Dworkin & Hartman, 1979; Horner, Alberts, Dawson, & Cook, 1994; Lazarus &

Logemann, 1987; Pauloski et al., 1994, Pauloski, Rademaker, Logemann, & Colangelo, 1998; Robbins, Levine, Maser, Rosenbek, & Kempster, 1993; Robbins, Logemann, & Kirschner, 1986). Lingual strengthening exercises are designed to improve bolus clearance from the oral cavity, specifically, to strip material from the tongue and palate in populations with reduced lingual strength such as individuals with stroke, traumatic brain injury, amyotrophic lateral sclerosis, Parkinson's disease, or oral cancer (Goodell, Shaker, Bowser, & Zamir, 1992; Lazarus et al., 2000; McNeil, Weismer, Adams, & Mulligan, 1990; Robbins et al., 2007; Solomon, Lorell, Robin, Rodnitzky, & Luschei, 1995; Thompson, Murdoch, & Stokes, 1995). Individuals with neurological impairments or those with head and neck cancer treated surgically or with radiotherapy can demonstrate reduced laryngeal motion for swallowing (Ertekin et al., 2002; Kotz, Abraham, Beitler, Wadler, & Smith, 1999; Lazarus et al., 1996; Leopold & Kagel, 1997; Logemann, Pauloski, Rademaker, & Colangelo, 1997b), with resultant reduction in opening within the upper esophageal sphincter (UES) region and poor bolus clearance through the lower pharynx. One particular exercise, the Shaker exercise, is a head lift exercise program designed to strengthen neck muscles and improve laryngeal excursion and UES opening for swallowing (Shaker et al., 1997, 2002).

Other types of OSMT introduce sensory input to the oropharynx, including mechanical, thermal (e.g., cold), and gustatory (e.g., sweet, salty, bitter, or sour) stimulation. As certain populations with dysphagia may demonstrate delayed or absent triggering of the pharyngeal motor response (Lazarus et al., 1996, 2000; Robbins & Levine, 1993; Robbins et al., 1986, 1993), these sensory stimulation treatments are designed to improve triggering and timing of the pharyngeal motor response as well as improve biomechanical and durational aspects of the swallow (e.g., shorten oral and pharyngeal transit times, and increase speed of oral and pharyngeal structural movement during swallowing). Given the complex nature of dysphagia, oftentimes OSMTs are combined (e.g., thermal stimulation and tongue strengthening exercises) or paired with other swallowing treatments (e.g., compensatory postures/maneuvers and dietary modifications). Yet, despite their widespread use, little is known about their effects on swallowing in the adult population.

Recently, the American Speech-Language-Hearing Association's (ASHA's) National Center for Evidence-Based Practice (N-CEP) began conducting systematic reviews to determine the state of the evidence for a number of clinical topics in the field of communication sciences and disorders, including OSMT. Evidence-based systematic reviews (EBSRs) utilize transparent, well-defined procedures to evaluate and summarize a body of scientific research, and their findings can be an invaluable and time-saving resource to SLPs seeking evidence to make informed treatment decisions. N-CEP, in conjunction with an expert evidence panel, initiated a systematic review on OSMT to examine its effect on various populations and outcomes. In doing this, the panel operationally defined OSMT as nonspeech activities involving sensory stimulation to or motor actions of the lips, jaw, tongue, soft palate, larynx, and respiratory muscles that are intended to influence the physiological underpinnings of the oropharyngeal mechanism and thus improve its functions. The clinical questions under review target both speech and swallowing outcomes, with the findings reported in a series of EBSR reports. Studies addressing the effect of OSMT on speech or swallowing in pediatric populations and studies involving electrical stimulation are the subjects of separate EBSR reports (Arvedson, Clark, Lazarus, Schooling, & Frymark, 2010; Clark, Lazarus, Arvedson, Schooling, & Frymark, 2009; McCauley, Strand, Lof, Schooling, & Frymark, 2009). The clinical research questions developed for this systematic review focused on the adult population; specifically, we investigated:

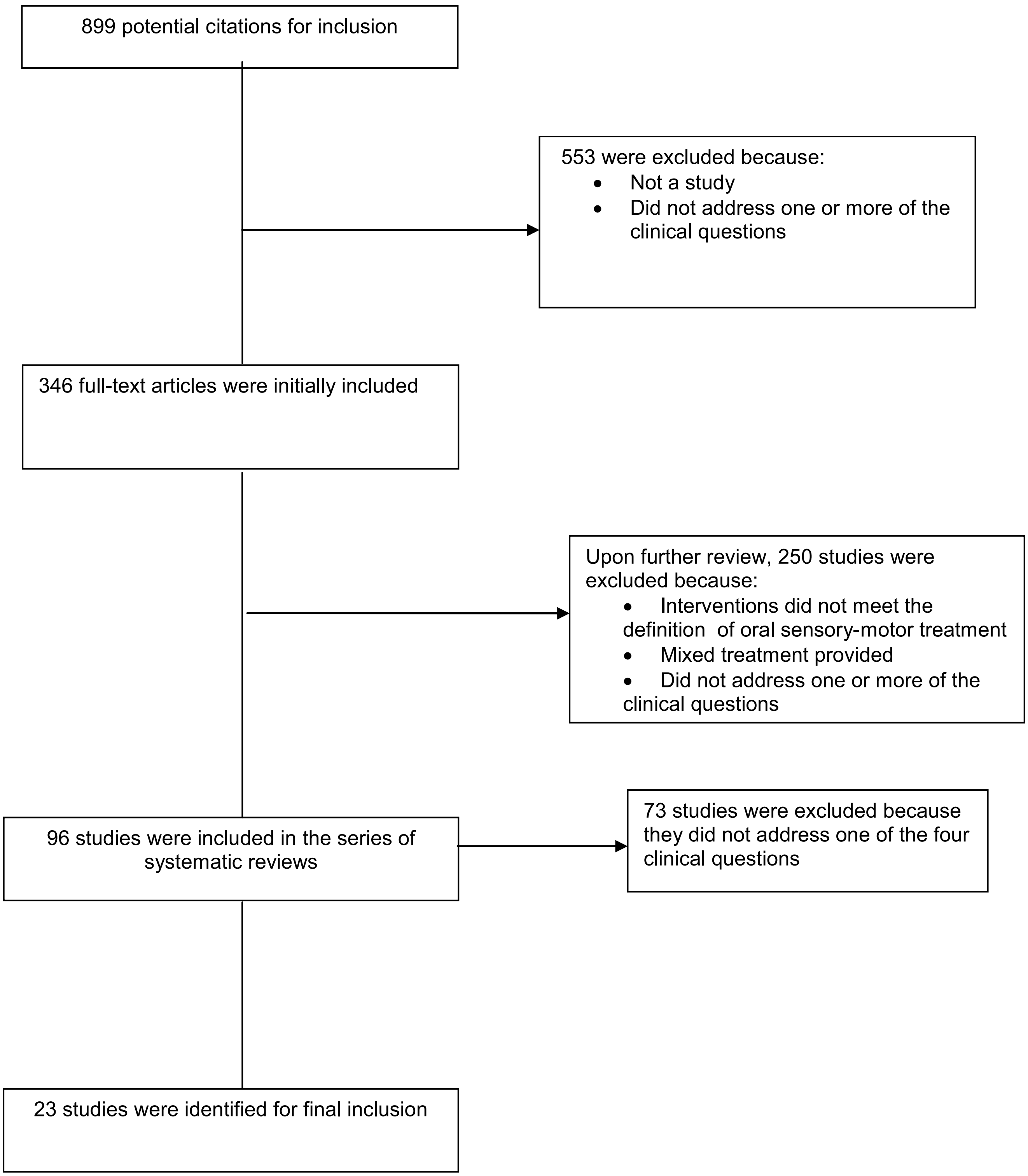
1. What are the effects of OSMT (other than electrical stimulation) on swallowing physiology (e.g., timing, swallowing pressures, and aspiration)?
2. What are the effects of OSMT (other than electrical stimulation) on pulmonary health (i.e., aspiration pneumonia)?
3. What are the effects of OSMT (other than electrical stimulation) on functional swallowing outcomes (e.g., oral feeding, weight gain, and swallowing quality of life)?
4. What are the effects of OSMT (other than electrical stimulation) on drooling or secretion management?

Method

Electronic literature searches were performed for the period from December 2006 through September 2007 using the following databases: Academic Search Premier, Cochrane Database of Systematic Reviews, Communications & Mass Media Complete, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Education Resources Information Center (ERIC), Embase, Evidence-Based Medicine Guidelines, Health Source: Nursing, HighWire Press, National Library for Health, PsycARTICLES, PsycINFO, PubMed, REHABDATA, Science Citation Index, ScienceDirect, Social Science Citation Index, SUMSearch, and TRIP Database. Additionally, searches in all ASHA journals and Google Scholar were completed, along with a manual search of references from all relevant articles. A total of 71 expanded key words used in the searches related to oral motor exercise, swallowing, and speech-language pathology.

Studies were eligible for inclusion if they were published in a peer-reviewed journal from 1960 to September 2007, were written in English, and contained original data addressing one or more of the four clinical questions under review. Exclusion criteria were studies incorporating surgical, medical, or pharmacological interventions as part of swallowing treatment, studies incorporating OSMT approaches combined with non-OSMT approaches or studies including food as part of intervention. Although studies examining electrical stimulation were excluded from this review, if a study compared a different OSMT to electrical stimulation, it was analyzed as part of this review also. Figure 1 schematizes the broader literature search pertaining to the series of EBSRs on OSMT for speech and swallowing. A full search of OSMT approaches, populations, and outcomes yielded a total of 899 citations. All abstracts were scanned independently by two N-CEP reviewers (the fourth and fifth authors); 346 citations met the initial inclusion criteria with 91% agreement. Of those, 250 citations were subsequently excluded because they did not directly address one or more of the larger set of clinical questions or report original data. Full-text articles of 96 studies were retrieved and again independently reviewed, with 23 studies pertaining to the effects of OSMT on swallowing in adult populations identified for inclusion in this EBSR.

Figure 1. Process for identification of included studies.



The two initial N-CEP reviewers, blinded to each other's results, evaluated included studies for methodological quality with 87% agreement. Table 1 outlines the eight quality indicators used to assess methodological quality—study design, assessor blinding, sampling/allocation, participant comparability/description, outcomes, significance, precision, and intention to treat (when applicable)—and their corresponding quality markers (Frymark et al., 2009). Each study received a point for each indicator that met the highest level of quality. For controlled trials, all eight quality indicators were relevant, leading to a maximum quality score of 8. For all other study designs, where an intention to treat analysis was not applicable, the highest quality score was 7. Because some of the appraisal domains were outcome-specific (e.g., precision), studies that addressed more than one clinical question were evaluated separately for each question. Final critical appraisals were reviewed by at least one member of the evidence panel who also completed the data extraction for the study. Data extraction points included participant and treatment characteristics, study findings, and outcomes. Agreement between the two initial reviewers and evidence panel members was greater than 98%. All discrepancies in ratings between N-CEP reviewers and the evidence panel were documented and resolved via consensus.

Table 1
Quality Indicators

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

Note: Boldface indicates highest level of quality marker.

In addition to assessing methodological rigor, each study was characterized as either 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 OSMT 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 OSMT as a condition to examine speech or swallowing abilities instead of as an intervention) were classified as exploratory research. A final synthesis of the corpus of scientific literature was compiled into an evidence table based on the clinical question and corresponding research category. For efficacy studies, participant information, treatment characteristics, and individual scores for each quality indicator were reported. For exploratory studies, a study summary and an overall quality score were reported. Effect sizes were calculated for outcome measures from efficacy studies whenever possible. For group studies, Cohen's *d* was calculated from group means and standard deviations. Magnitude of effect size was determined using Cohen's benchmarks for small, medium, and large effects as 0.2, 0.5, and 0.8, respectively (Cohen, 1988).

Results

Of the 23 studies identified for inclusion in this EBSR, 20 addressed the effects of OSMT on swallowing physiology (Question 1), one addressed the effects of OSMT on pulmonary health (Question 2), eight addressed the effects of OSMT on functional swallowing outcomes (Question 3), and one addressed the effectiveness on drooling/secretion management in adults (Question 4).

Clinical Question 1: What Are the Effects of OSMT on Swallowing Physiology in Adults?

Of the 20 studies reporting data related to OSMT and swallowing physiology in adults, four met the criteria for efficacy studies, and 16 were exploratory.

Efficacy Studies

Table 2 provides a detailed description of the participants and intervention reported in the four efficacy studies. These included a wide range of participants, interventions, and study designs. Logemann, Pauloski, Rademaker, and Colangelo (1997a) examined the effects of range of motion and/or coordination exercises of the lips, tongue, jaw, and larynx on swallowing in a group of patients surgically treated for oral and oropharyngeal cancer. Rosenbek, Robbins, Fishback, and Levine (1991) examined the effects of thermal-tactile stimulation on swallowing physiology in a group of patients with multiple cerebrovascular accidents. Shaker and colleagues (2002) examined the effects of a head lift exercise (Shaker exercises) on swallowing physiology in a mixed group of patients with dysphagia who had a reduced/abnormal UES opening. Hwang, Choi, Ko, and Leem (2007) examined the combined treatments of thermal-tactile stimulation, oral stimulation, oral massage, digital manipulation, cervical range of motion, and general oral hygiene on swallow physiology in a mixed group of patients who were intubated due to respiratory distress compared with a control group who received only general oral hygiene. Frequency, duration, and intensity of treatments were reported in all four studies.

Table 2

Participant and Treatment Characteristics: Swallowing Physiology (Question 1) Efficacy Studies

Citation	*N*	Age (years)	Gender	Medical and/or SLP diagnosis as reported in article	Intervention	Treatment schedule and amount	Outcome measure(s)	Significance	Effect size	Quality marker score
Hwang et al. (2007)	33	*M* = 58.5	17 M, 16 F	Intubation for at least 48 hr due to respiratory distress	**Experimental:**– Combination of thermal-tactile stimulation, oral stimulation, oral massage, digital manipulation, cervical range of motion, and general oral hygiene **Control:** General oral hygiene	15 min a day, 6 days/week for an average of 7.3 days	Aspiration	*ns*	NR	6/8
							Silent aspiration	*ns*	NR	
							Swallowed volume	*ns*	0.19	
							Pharyngeal transit time	*ns*	0.33	
							Oral transit time	$p < .001$	5.33	
							Oropharyngeal transit time	$p < .001$	2.88	
							OPSE	$p < .001$	1.51	
Logemann, et al. (1997a)	102	NR	NR	Surgically treated oral and oropharyngeal cancer	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 5–10 min, 10 times/day.	OPSE for liquid	$p = .01$	0.57	2/7
							OPSE for paste	$p = .04$	0.48	
Rosenbek et al. (1991)	7	65–77, *M* = 70.7	7 M	Multiple CVAs and dysphagia	Thermal application of chilled size 00 laryngeal mirror to anterior faucial pillars	Participants received an average of 18 trials (a trial was defined as 6 strokes, 3 to each faucial pillar), 5 times/day during the 2 treatment phases.	Duration of oral transit, stage transition, pharyngeal transit, pharyngeal response, hyoid maximum elevation, hyoid maximum anterior movement, UES opening, and total transit	NR	NR	3/7
Shaker et al.	27	62–89,	25 M,	Abnormal UES	**Experimental:**- 3	**Experimental:** 3	Anteroposterior and	*ns*	NR	6/8

(2002)	*M* = 73.4	2 F	opening and dysphagia secondary to one of the following: CVA, carotid endarterectomy, pharyngeal radiation, myocardial revascularization, or brain tumor.	sustained 1-min head raisings in supine position with a 1-min rest between trials followed by 30 consecutive head raises **Control:** Passive tongue lateralization	times/day for 6 weeks **Control:** 15 repetitions, 3 times/day for 6 weeks	lateral dimensions of the UES opening during swallows

Note: NR = not reported or calculable; OPSE= oropharyngeal swallow efficiency; CVA= cerebrovascular accident; UES = upper esophageal sphincter.

Table 3 displays the quality marker ratings for each study. Two studies (Hwang et al., 2007; Shaker et al., 2002) were controlled trials, one study was a single-subject design (Rosenbek et al., 1991), and the fourth (Logemann et al., 1997a) was a cohort study. When examining the methodological rigor for each study, all four were lacking in at least one area of quality. Data were not reported in a manner in which statistical significance was calculable (Rosenbek et al., 1991). Neither effect size nor confidence interval was reported or calculable in Rosenbek et al. (1991) and Shaker et al. (2002). The assessors were not blinded in Logemann et al. (1997a). Participant comparability was not reported in Logemann et al., and participants were hand-picked in that study. In the two controlled clinical trials studies (Hwang et al., 2007; Shaker et al., 2002), intention to treat was not stated.

Two studies (Hwang et al., 2007; Logemann et al., 1997a) provided sufficient information and used measures of swallowing physiology for which treatment effect sizes were calculable. The seven effect sizes ranged from 0.19 to 5.33. In Logemann et al. (1997a), range of motion had a small positive effect on oropharyngeal swallow efficiency (OPSE) for paste (d = 0.48) and a medium effect (d = 0.57) for liquid swallows. In Hwang et al. (2007), the effect of OSMT compared to general oral hygiene varied greatly. OSMT had a negligible effect (d = 0.19) on swallowed volume and a small effect (d = 0.33) on pharyngeal transit time. OSMT had very large effects on oral transit time (d = 5.33), oropharyngeal transit time (d = 2.88), and oropharyngeal swallowing efficiency (d = 1.51). No significant differences were noted between the two groups on measures of aspiration or silent aspiration. Effect sizes were not reported or calculable for these measures. Shaker et al. (2002) and Rosenbek et al. (1991) provided further evidence on the effects of OSMT, although effect sizes were not reported or calculable in either. Shaker et al. reported significant improvement over baseline scores for the OSMT group in UES opening and laryngeal excursion during swallowing. Although the control group did not show similar improvement from baseline scores, the between-group differences for the intervention and control groups did not reach statistical significance for any of the swallowing physiology measures. Rosenbek et al. did not provide sufficient data to analyze the findings statistically.

Table 3
Appraisal Summary: Swallowing Physiology (Question 1) Efficacy Studies

Citation	Study design	Blinding	Allocation	Participants	Outcomes	Significance	Precision	Intention to treat
Hwang et al. (2007)	Controlled trial	Assessors blinded	Random sample adequately described	Groups comparable at baseline on important factors (between-subjects design)	Validity unknown, but appears reasonable; reliable	*P* value reported or calculable	Effect size and confidence interval reported or calculable	Not stated
Logemann et al. (1997a)	Cohort study	Not stated	Convenience sample/hand-picked sample	Comparability not reported	Validity unknown, but appears reasonable; reliable	*P* value reported or calculable	Effect size and confidence interval reported or calculable	Not applicable
Rosenbek et al. (1991)	Single-subject design	Assessors blinded	Random sample inadequately described	Participant(s) adequately described (within-subjects design)	At least one primary outcome measure is valid and reliable	*P* value neither reported nor calculable	Neither effect size nor confidence interval reported or calculable	Not applicable
Shaker et al. (2002)	Controlled trial	Assessors blinded	Random sample adequately described	Groups comparable at baseline on important factors (between-subjects design)	At least one primary outcome measure is valid and reliable.	*P* value reported or calculable	Neither effect size nor confidence interval reported or calculable	Not stated

Note: Shaded areas indicate highest level of quality in each category.

Exploratory Studies

Appendix A provides a detailed description of the intervention and participants reported in the exploratory studies. The 16 exploratory studies examined the effects of various OSMT programs on swallow physiology, including an oral stimulating appliance, lingual strengthening/exercise, motor and sensory stimulation (comprising oral stimulating plate application, velopharyngeal closure training, and body and orofacial regulation), thermal/mechanical/gustatory stimulation, head lift exercise, myofunctional therapy, and gum chewing.

Thermal/Mechanical/Gustatory Stimulation. Seven studies (Ali, Laundl, Wallace, deCarle, & Cook, 1996; Bove, Månsson, & Eliasson, 1998; de Lama Lazzara, Lazarus, & Logemann, 1986; Kaatzke-McDonald, Post, & Davis, 1996; Rosenbek, Roecker, Wood, & Robbins, 1996; Sciortino, Liss, Case, Gerritsen, & Katz, 2003; Selinger, Prescott, & McKinley, 1990) evaluated the use of thermal, mechanical, and/or gustatory stimulation in either healthy individuals or adults with dysphagia. Rosenbek et al. (1996) reported significant positive changes in swallowing physiology parameters, specifically stage transition duration (p = .046) and total swallow duration (p = .005) following thermal-tactile stimulation. Bove et al. (1998) found no significant change in the ability of healthy individuals to elicit multiple swallows following thermal-tactile stimulation. Selinger et al. (1990) also reported no change in swallowing physiology (i.e., aspiration) following thermal stimulation in a patient with dysphagia. However, statistical significance of these results was not reported or calculable. Ali et al. (1996), de Lama Lazzara et al. (1986), Kaatzke-McDonald et al. (1996), and Sciortino et al. (2003) reported mixed results. Ali et al. reported significant differences in the swallowing physiology of healthy participants in pharyngeal clearance with cold stimulation (p = .047) and anesthesia (p = .002) but no differences in oral or pharyngeal transit time with cold stimulation or anesthesia. Sciortino et al. found significantly shorter latency to first swallow following a combination of mechanical, cold, and gustatory stimulation as compared to no stimulation (p = .045) but no significant differences in the duration of submental surface electromyography activities in healthy individuals. De Lama Lazzara et al. reported significant improvement in pharyngeal transit time (p = .0015) and total transit time (p = .0252) for paste swallows but not for liquid swallows in a group of individuals with neurological impairment treated with thermal-tactile stimulation. Kaatzke-McDonald et al. reported improvement in latency of swallowing following cold stimulation (p = .05) and number of evoked swallows following cold (p < .0001), chemical (p < .0001), or combined chemical/tactile/warm (p = .01) stimulation in healthy adults.

Strengthening and Exercise. Five studies (Kikutani et al., 2006; Robbins et al., 2005, 2007; Shaker et al., 1997; Tzakis, Kiliaridis, & Carlsson, 1989) examined the effects of strengthening activities or exercise on swallowing physiology outcomes. Of these, three studies showed mixed results. Shaker et al. (1997) examined the effects of head lift exercise on temporal and structural movement of the larynx, hyoid, and UES region and in intrabolus pressures in a group of healthy individuals. The experimental group showed significant improvement (p < .05) in anteroposterior diameter of maximum UES opening, UES cross-sectional area, maximum anterior excursion of the larynx, and intrabolus hypopharyngeal pressure. However, no differences were noted in other swallowing physiology parameters that were measured. These included area of UES opening at maximum opening diameter, duration of UES opening, maximum superior excursion of the larynx, maximum superior and anterior excursion of the hyoid, and maximum lateral diameter of UES. No significant changes were seen in any temporal or structural movement measures for the control group.

Robbins et al. (2005) found some significant increases in swallow pressures but no changes on a penetration-aspiration scale in a group of healthy elderly participants following a lingual strengthening program. Robbins et al. (2007) evaluated the use of this same lingual strengthening program in adults with dysphagia secondary to a stroke and reported significant improvement in swallow pressures, penetration-aspiration scale rating, and durational and oropharyngeal residue measures under certain swallow and bolus conditions only. A negative effect of OSMT was noted in a different study. Specifically, Tzakis et al. (1989) reported a significant decline in masticatory efficiency immediately following a 30-min chewing session both before and after (p < .001) training in 10 healthy individuals. They found no significant difference in masticatory efficiency over a 1-month posttraining period following gum chewing. Kikutani et al. (2006) examined swallowing in undernourished elderly patients who were placed on nutritional supplements plus an oral functional training exercise program compared with a group receiving nutritional supplements only, but the authors did not provide adequate data to analyze the findings statistically.

Oral Stimulating Appliance. Three studies (Basar, Yilmaz, & Haberfellner, 2003; Hagg & Larsson, 2004; Selley, 1985) investigated the use of oral stimulating appliances in individuals with dysphagia resulting from cerebral palsy or stroke. Hagg and Larsson (2004) found no significant changes in swallow physiology measures following use of an oral stimulating plate combined with manual orofacial stimulation and exercise. Basar et al. (2003) and Selley (1985) did not report or present data in a manner in which statistical significance was calculable.

Myofunctional Treatment. Hahn and Hahn (1992) reported on the use of myofunctional therapy on tongue thrust during swallowing but did not provide sufficient data to analyze the findings statistically.

Clinical Question 2: What Are the Effects of OSMT on Pulmonary Health in Adults?

One efficacy study (Hwang et al., 2007) was found to examine the effectiveness of OSMT on pulmonary health in adults. No exploratory studies were found that addressed this clinical question.

Efficacy Study

Table 4 provides a detailed description of the intervention and participants reported in the one efficacy study. Table 5 displays the quality marker ratings. Hwang et al. (2007) examined pneumonia rate in a group of patients who were intubated due to respiratory distress and who received OSMT while intubated. The experimental group received a combination of thermal-tactile stimulation, oral stimulation, oral massage, digital manipulation, cervical range of motion, and general oral hygiene. The control group received general oral hygiene. No significant differences in pneumonia rate were found for the two groups. Although this study utilized an experimental design, these authors did not provide sufficient information to allow effect sizes to be calculated.

Table 4

Participant and Treatment Characteristics: Pulmonary Health (Question 2) Efficacy Study

Citation	*N*	Age (years)	Gender	Medical and/or SLP diagnosis as reported in article	Intervention	Treatment schedule and amount	Outcome measure(s)	Significance	Effect size	Quality marker score
Hwang et al. (2007)	33	M = 58.5	17 M, 16 F	Intubation for at least 48 hr due to respiratory distress	**Experimental:** Combination of thermal-tactile stimulation, oral stimulation, oral massage, digital manipulation, cervical range of motion, and general oral hygiene **Control:** General oral hygiene	15 min/day, 6 days/week for an average of 7.3 days	Pneumonia rate	*ns*	NR	5/8

Table 5

Appraisal Summary: Pulmonary Health (Question 2) Efficacy Study

Citation	Study design	Blinding	Allocation	Participants	Outcomes	Significance	Precision	Intention to treat
Hwang et al. (2007)	Controlled trial	Assessors blinded	Random sample adequately described	Groups comparable at baseline on important factors (between-subjects design)	Validity unknown, but appears reasonable; reliable	*P* value reported or calculable	Neither effect size nor confidence interval reported or calculable	Not stated

Note: Shaded areas indicate highest level of quality in each category.

Clinical Question 3: What Are the Effects of OSMT on Functional Swallowing Outcomes in Adults?

Efficacy Studies

Tables 6 and 7 provide detailed descriptions of the intervention and participants reported in the three efficacy studies and the quality marker ratings for each study. Treatments in these studies included head lifts and the combined therapeutic strategies of thermal-tactile stimulation, oral stimulation, oral massage, digital manipulation, and cervical range of motion. Freed, Freed, Chatburn, and Christian (2001) reported improvement in swallow function ($p < .001$) based on a 7-point scale following electrical stimulation as compared to the OSMT of thermal-tactile stimulation in a group of stroke patients with dysphagia. These authors, however, did not report whether the examiners and researchers were blinded to intervention. In addition, there was no information given on the validity or reliability of the outcome scale, or whether the sample of participants was hand-picked/convenience sampled, and effect sizes were not reported, nor were they calculable. Shaker et al. (2002) reported improvement in swallowing outcomes utilizing the Functional Outcome Assessment of Swallowing Scale ($p < .01$) in a group of 27 dysphagic patients with mixed diagnoses who underwent head lift exercise compared to a control group who underwent passive tongue lateralization. Effect sizes were not calculable in this study. In addition, the validity of the outcome measure is unknown but appeared reasonable. Hwang et al. (2007) reported a small effect ($d = 0.49$) but no statistically significant difference in days to oral intake in an experimental group who underwent a combined exercise program of thermal-tactile stimulation, oral stimulation, oral massage, digital manipulation, cervical range of motion, and general oral hygiene as compared to a control group who underwent general oral hygiene. Data analysis by an intention to treat standard was not reported in this study.

Table 6

Participant and Treatment Characteristics: Functional Swallowing Outcomes (Question 3) Efficacy Studies

Citation	*N*	Age (years)	Gender	Medical and/or SLP diagnosis as reported in article	Intervention	Treatment schedule and amount	Outcome measure(s)	Significance	Effect size	Quality marker score
Freed et al. (2001)	99	49–101, *M* = 76.5	53 M, 46 F	Primary diagnosis of stroke with dysphagia	**Experimental group:** Electrical stimulation delivered at 80 Hz and at an intensity level set by the individual's tolerance **Control group:** Thermal-tactile stimulation	**Intervention group:** Daily 60-min sessions until criteria were reached **Control group:** 20-min sessions 3 times/day	Swallow Function Scoring System (7-point swallowing scale)	$p < .0001$	NR	2/8
Hwang et al. (2007)	33	*M* = 58.5	17 M, 16 F	Intubation for at least 48 hr due to respiratory distress	**Experimental:** Combination of thermal-tactile stimulation, oral stimulation, oral massage, digital manipulation, cervical range of motion, and general oral hygiene **Control:** general oral hygiene	15 min/day, 6 days/week for an average of 7.3 days	Days to oral intake	*ns*	0.49	6/8
Shaker et al. (2002)	27	62–89, *M* = 73.4	25 M, 2 F	Abnormal upper esophageal sphincter opening and dysphagia secondary to one of the following: CVA, carotid endarterectomy, pharyngeal radiation, myocardial revascularization, or brain tumor	**Experimental:** 3 sustained 1-min head raisings in supine position with a 1-min rest between trials followed by 30 consecutive head raises **Control:** Passive tongue lateralization	**Experimental:** 3 times/day for 6 weeks **Control:** 15 repetitions, 3 times/day for 6 weeks	Functional Outcome Assessment of Swallowing	$p < .01$	NR	4/8

Table 7

Appraisal Summary: Functional Swallowing Outcomes (Question 3) Efficacy Studies

Citation	Study design	Blinding	Allocation	Participants	Outcomes	Significance	Precision	Intention to treat
Freed et al. (2001)	Controlled trial	Not stated	Convenience sample/hand-picked sample	Groups/participants not comparable at baseline	Invalid and/or unreliable	*P* value reported or calculable	Neither effect size nor confidence interval reported or calculable	Not analyzed by intention to treat
Hwang et al. (2007)	Controlled trial	Assessors blinded	Random sample adequately described	Groups comparable at baseline on important factors (between-subjects design)	Validity unknown, but appears reasonable; reliable	*P* value reported or calculable	Effect size and confidence interval reported or calculable	Not stated
Shaker et al. (2002)	Controlled trial	Assessors not blinded	Random sample adequately described	Groups comparable at baseline on important factors (between-subjects design)	Validity unknown, but appears reasonable; reliable	*P* value reported or calculable	Neither effect size nor confidence interval reported or calculable	Not stated

Note: Shaded areas indicate highest level of quality in each category.

Exploratory Studies

Five studies were exploratory in scope and incorporated a wide range of interventions and populations (see Appendix B). Beurskens and Heymans (2004) and Kikutani et al. (2006) reported significant positive changes in functional swallowing outcomes subsequent to OSMT. Beurskens and Heymans examined mime therapy (automassage of the face and neck, muscle stretching, and kneading, breathing, and relaxation exercises) in a group of patients with peripheral facial nerve paresis and reported improvement in eating and drinking, as self-reported by the patients. Kikutani et al. reported significant weight gain in a group of elderly individuals who received an oral functioning training program plus nutritional supplements; there was no change in the control group who received nutritional supplements only.

Robbins et al. (2007) reported mixed results, and Neumann, Bartolome, Buchholz, and Prosiegel (1995) reported no significant differences. Robbins et al. examined the effects of lingual exercise on swallowing quality of life using the SWAL-QOL questionnaire (McHorney et al., 2002), in a group of dysphagic stroke patients. These authors reported significant change in three of 11 subscales, namely Fatigue, Communication, and Mental. Neumann et al. compared the use of OSMT plus direct therapy (i.e., strategies during swallowing, including the supraglottic swallow and Mendelsohn maneuver) to OSMT only in patients with dysphagia and found no significant difference between the groups on measures of total oral feeding. Hagg and Larsson (2004) reported on patient self-assessment relative to the impact of dysphagia following OSMT intervention but did not report adequate data to analyze the findings statistically.

Clinical Question 4: What Are the Effects of OSMT on Drooling/Secretion Management in Adults?

Exploratory Study

One exploratory study met the inclusion criteria and addressed this clinical question (see Appendix C). Selley (1985) examined the effects of a palatal training appliance on drooling and ability to swallow liquids and foods without choking in a group of dysphagic or drooling patients. Statistical significance was not reported, nor was it calculable in this study. In addition, intervention schedule and length of treatment were not stated. Furthermore, the age range and mean ages of the participants were not reported.

Discussion

This EBSR examined the impact of oral motor exercise on swallowing impairment. Four clinical questions were targeted in this review to examine a number of outcomes, including swallowing physiology, pulmonary health, functional swallowing, and drooling/secretion management. Based on the results of this EBSR, it is difficult to support or refute the use of OSMT as a means of improving swallowing in adults with dysphagia. Although the corpus of studies found was reasonable in size, most of the studies were considered exploratory, and no pattern of findings emerged. Moreover, methodological weaknesses across the included studies further limit the utility of the current findings. As can be seen in Tables 3–7, these studies did not meet many of the standards of scientific rigor needed for treatment research. However, some of these studies did meet some of the criteria for efficacy. Examination of the literature on the effects of OSMT on swallow physiology identified four articles that met most of the criteria for efficacy: Logemann et al. (1997a) showed that OSMT that was specifically focused on range of motion improved overall OPSE on swallows of certain viscosities. Hwang et al. (2007) examined the effects of oral hygiene and OSMT (thermal-tactile stimulation, oral stimulation, oral massage, digital manipulation, and cervical range of motion) and reported improvement in OPSE measures. Although effect size could not be calculated, both Rosenbek et al. (1991) and Shaker et al. (2002) showed some change in function with thermal-tactile stimulation and the Shaker exercises, respectively. Although the exploratory studies do not include patient populations, the results based on healthy individuals are encouraging. Varied techniques showed promise, with adequate information to determine effect size. These techniques included motor and sensory stimulation, thermal-tactile stimulation, tongue strengthening, and sensory stimulation including mechanical, cold, and gustatory. Only one study achieved efficacy rating for effects of OSMT on pulmonary status, with no studies considered for exploratory status. This is an area that would benefit from randomized controlled trials to examine the effects of OSMT on pulmonary function.

Three studies examining the effects of OSMT on swallowing outcomes reached efficacy level. These included mixed OSMT, as cited above in Hwang et al. (2007), the Shaker exercise (head lift) (Shaker et al., 2002), and electrical stimulation (Freed et al., 2001). However, all three studies were lacking in some aspect of methodology, including no blinding, participants being hand-picked, uncalculable effect sizes, and unreliable or unvalidated outcome measures. The exploratory studies had similar shortcomings. However, Robbins et al. (2007), examining the effects of lingual resistance exercise in individuals with neurological impairment, was the strongest in this group in terms of quality marker scores.

No studies reached efficacy level when examining the literature on OSMT and drooling/secretion management. The one exploratory study by Selley (1985) examining the effects of a palatal appliance on drooling/secretion management did not include statistically significant data. In addition, it did not include intervention schedule, length of treatment, age range, and mean ages of the participants.

Limitations of the Current Review

No attempt was made to locate unpublished literature. This may have resulted in an overrepresentation of positive treatment effects (i.e., publication bias) in this EBSR. Additionally, due to limited translation resources, only articles published in English were included. Therefore, it is possible that some studies addressing the use of OSMT in adults were not found. The studies investigating OSMT differed across many of the variables examined, including types of participants, treatment schedules, interventions, outcome measures, and severity. This inconsistency makes it difficult to determine the effect of these variables on outcomes and to compare effects across studies.

Summary

In conclusion, support for the use of OSMT is pending well-designed studies with appropriate experimental controls and statistical power. To demonstrate efficacy of OSMT to improve swallowing, studies need to be conducted at a higher level of evidence and should include experimental design, calculable effect size, blinding of examiners, reliable and valid interventions, outcome measures, and adequate information that is replicable. Only with studies that incorporate these factors can more complete evidence be evaluated to assess the use and viability of OSMT on swallow functioning. Future studies examining treatment techniques need to include randomized controlled clinical trials for which the quality markers and levels of evidence are sufficiently high to provide adequate evidence of efficacy. However, as no current studies to date contain all of the quality markers for scientific rigor, current best evidence should be considered when determining how to best treat swallowing disorders. Best evidence, client/patient values, and clinical expertise should be incorporated into decisions about use of treatment techniques (Sackett, Straus, Richardson, Rosenberg, & Haynes, 2000). Furthermore, SLPs should keep abreast of research and treatment outcome/efficacy studies related to swallow therapy techniques in order to provide the most appropriate and potentially effective care relative to the use of OSMTs in intervention.

ACKNOWLEDGMENTS: This evidence-based review was supported by the American Speech-Language-Hearing Association's National Center for Evidence-Based Practice in Communication Disorders (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. Rebecca McCauley, Dr. Edythe Strand, and Dr. Gregory Lof. We also thank the following individuals who contributed to the preparation of this document: Rob Mullen, N-CEP Director; Beverly Wang, N-CEP Information Manager; and Hillary Leech, N-CEP Research Assistant.

References

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

Agency for Health Care Policy and Research. (1999). *Diagnosis and treatment of swallowing disorders (dysphagia) in acute-care stroke patients* (Evidence Report/Technology Assessment No. 8, AHCPR Pub. No. 99-E024). Rockville, MD: Author.

*Ali, G. N., Laundl, T. M., Wallace, K. L., deCarle, D. J., & Cook, I. J. (1996). Influence of cold stimulation on the normal pharyngeal swallow response. *Dysphagia, 11*, 2–8.

Arvedson, J., Clark, H., Lazarus, C., Schooling, T., & Frymark, T. (2010). Evidence-based systematic review: Effects of oral motor interventions on feeding and swallowing in preterm infants. *American Journal of Speech-Language Pathology, 19,* 321–340. doi:10.1044/1058-0360(2010/09-0067).

*Basar, P., Yilmaz, S., & Haberfellner, H. (2003). Use of an Innsbruck sensorimotor activator and regulator (ISMAR) in the treatment of oral motor dysfunctions: A single case report. *International Journal of Rehabilitation Research, 26,* 57–59.

*Beurskens, C. H., & Heymans, P. G. (2004). Physiotherapy in patients with facial nerve paresis: Description of outcomes. *American Journal of Otolaryngology, 25,* 394–400.

*Bove, M., Månsson, I., & Eliasson, I. (1998). Thermal oral-pharyngeal stimulation and elicitation of swallowing. *Acta Oto-laryngologica, 118*, 728–731.

Clark, H., Lazarus, C., Arvedson, J., Schooling, T., & Frymark, T. (2009). Evidence-based systematic review: Effects of neuromuscular electrical stimulation on swallowing and neural activation. *American Journal of Speech-Language Pathology, 18*, 361–375.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Mahwah, NJ: Erlbaum.

Daniels, S.K., Brailey, K., & Foundas, A.L. (1999). Lingual discoordination and dysphagia following acute stroke: Analyses of lesion localization. *Dysphagia, 14,* 85–92.

*de Lama Lazzara, G., Lazarus, C., & Logemann, J. A. (1986). Impact of thermal stimulation on the triggering of the swallowing reflex. *Dysphagia, 1,* 73–77.

Dworkin, J., & Hartman, D. (1979). Progressive speech deterioration and dysphagia in amyotrophic lateral sclerosis: Case report. *Archives of Physical Medicine and Rehabilitation, 60,* 423–425.

Ertekin, C., Tarlaci, S., Aydogdu, I., Kiylioglu, N., Yuceyar, N., Turman, A.B., … Esmeli, F. (2002). Electrophysiological evaluation of pharyngeal phase of swallowing in patients with Parkinson's disease. *Movement Disorders,17,* 942–949.

*Freed, M. L., Freed, L., Chatburn, R. L., & Christian, M. (2001). Electrical stimulation for swallowing disorders caused by stroke. *Respiratory Care, 46,* 466–474.

Frymark, T., Schooling, T., Mullen, R., Wheeler-Hegland, K., Ashford, J., McCabe, D., …Smith-Hammond, C. (2009). Evidence-based systematic review: Oropharyngeal dysphagia behavioral treatments. Part 1 – Background and methodology. *Journal of Rehabilitation Research and Development, 46*, 175–184.

Goodell, C., Shaker, R., Bowser, M., & Zamir, Z. (1992). Effect of aging and cerebrovascular accident (CVA) on nondeglutitive lingual pressure. *Gastroenterology, 102,* A554.

Hagg, M., & Larsson, B. (2004). Effects of motor and sensory stimulation in stroke patients with long-lasting dysphagia. Dysphagia, 19,* 219–230.

*Hahn, V., & Hahn, H. (1992). Efficacy of oral myofunctional therapy. *International Journal of Orofacial Myology, 18,* 21–23.

Horner, J., Alberts, M. J., Dawson, D. V., & Cook, D. M. (1994). Swallowing in Alzheimer's disease. *Alzheimer Disease & Associated Disorders, 8,* 177–189.

Howden, C.W. (2004). Management of acid-related disorders in patients with dysphagia. *American Journal of Medicine, 117*(5, Suppl. 1), 44S–48S.

*Hwang, C. H., Choi, K. H., Ko, Y. S., & Leem, C. M. (2007). Pre-emptive swallowing stimulation in long-term intubated patients. *Clinical Rehabilitation, 21,* 41–46.

*Kaatzke-McDonald, M. N., Post, E., & Davis, P. J. (1996). The effects of cold, touch, and chemical stimulation of the anterior faucial pillar on human swallowing. *Dysphagia, 11,* 198–206.

*Kikutani, T., Enomoto, R., Tamura, F., Oyaizu, K., Suzuki, A., & Inaba, S. (2006). Effects of oral functional training for nutritional improvement in Japanese older people requiring long-term care. *Gerodontology, 23*, 93–98.

Kotz, T., Abraham, S., Beitler, J., Wadler, S., & Smith, R. V. (1999). Pharyngeal transport dysfunction consequent to an organ-sparing protocol. *Archives of Otolaryngology—Head & Neck Surgery, 125,* 410–413.

Lazarus, C., & Logemann, J. (1987). Swallowing disorders in closed head trauma patients. *Archives of Physical Medicine and Rehabilitation, 68,* 79–87.

Lazarus, C., Logemann, J. A., Pauloski, B. R., Colangelo, L. A., Kahrilas, P. J., Mittal, B. B., & Pierce, M. (1996). Swallowing disorders in head and neck cancer patients treated with radiotherapy and adjuvant chemotherapy. *Laryngoscope, 106,* 1157–1166.

Lazarus, C. L., Logemann, J. A., Pauloski, B. R., Rademaker, A. W., Larson, C. R., Mittal, B. B., & Pierce, M. (2000). Swallowing and tongue function following treatment for oral and pharyngeal cancer. *Journal of Speech, Language, and Hearing Research, 43,* 1011–1023.

Leopold, N. A., & Kagel, M. C. (1997). Pharyngo-esophageal dysphagia in Parkinson's disease. *Dysphagia, 12,* 11–18.

List, M.A., Siston, A., Haraf, D., Schumm, P., Kies, M., Stenson, K., & Vokes, E. E. (1999). Quality of life and performance in advanced head and neck cancer patients on concomitant chemoradiotherapy: A prospective examination. *Journal of Clinical Oncology, 17,* 1020–1028.

Logemann, J. A. (1998). *Evaluation and treatment of swallowing disorders* (2nd ed.). Austin, TX: Pro-Ed.

*Logemann, J. A., Pauloski, B. R., Rademaker, A. W., & Colangelo, L. A. (1997a). Speech and swallowing rehabilitation for head and neck cancer patients. *Oncology, 11*, 651–664.

Logemann, J. A., Pauloski, B. R., Rademaker, A. W., & Colangelo, L. (1997b). Super-supraglottic swallow in irradiated head and neck cancer patients. *Head & Neck, 19,* 535–540.

McCauley, R., Strand, E., Lof, G., Schooling, T., & Frymark, T. (2009). Evidence-based systematic review: Effects of nonspeech oral motor exercises on speech. *American Journal of Speech-Language Pathology,18,* 343–360.

McConnel, F. M. S. (1988). Analysis of pressure generation and bolus transit during pharyngeal swallowing. *Laryngoscope, 98,* 71–78.

McHorney, C., Robbins, J., Lomax, K., Rosenbek, J., Chignell, K., Kramer, A., & Bricker, D. (2002). The SWAL-QOL and SWAL-CARE outcomes tool for oropharyngeal dysphagia in adults: III. Documentation of reliability and validity. *Dysphagia, 17*, 97-114.

McNeil, M. R., Weismer, G., Adams, S., & Mulligan, M. (1990). Oral structure nonspeech motor control in normal, dysarthric, aphasic and apraxic speakers: Isometric force and static position control. *Journal of Speech and Hearing Research, 33,* 255–268.

Morris, H. (2006). Dysphagia in the elderly—a management challenge for nurses. *British Journal of Nursing, 15,* 558–562.

*Neumann, S., Bartolome, G., Buchholz, D., & Prosiegel, M. (1995). Swallowing therapy of neurologic patients: Correlation of outcome with pretreatment variables and therapeutic methods. *Dysphagia, 10,* 1–5.

Pauloski, B. R., Logemann, J. A., Rademaker, A. W., McConnel, F. M. S., Stein, D., Beery, Q., … Baker, T. (1994). Speech and swallowing function after oral and oropharyngeal resections: One-year follow-up. *Head & Neck, 16,* 313–322.

Pauloski, B. R., Rademaker, A. W., Logemann, J. A., & Colangelo, L. (1998). Speech and swallowing in irradiated and nonirradiated postsurgical oral cancer patients. *Otolaryngology—Head and Neck Surgery, 118,* 616–624.

*Robbins, J., Gangnon, R. E., Theis, S. M., Kays, S. A., Hewitt, A. L., & Hind, J. A. (2005). The effects of lingual exercise on swallowing in older adults. *Journal of the American Geriatrics Society, 53,* 1483–1489.

*Robbins, J., Kays, S. A., Gangnon, R. E., Hind, J. A., Hewitt, A. L., Gentry, L. R., & Taylor, A. J. (2007). The effects of lingual exercise in stroke patients with dysphagia. *Archives of Physical Medicine and Rehabilitation, 88,* 150–158.

Robbins, J., & Levine, R. (1993). Swallowing after lateral medullary syndrome plus. *Clinics in Communicative Disorders, 3,* 45–55.

Robbins, J., Levine, R. L., Maser, A., Rosenbek, J. C., & Kempster, G. B. (1993). Swallowing after unilateral stroke of the cerebral cortex. *Archives of Physical Medicine and Rehabilitation, 74,* 1295–1300.

Robbins, J., Logemann, J., & Kirschner, H. (1986). Swallowing and speech production in Parkinson's disease. *Annals of Neurology, 19,* 283–287.

*Rosenbek, J. C., Robbins, J., Fishback, B., & Levine, R. L. (1991). Effects of thermal application on dysphagia after stroke. *Journal of Speech and Hearing Research, 34,* 1257–1268.

*Rosenbek, J. C., Roecker, E. B., Wood, J. L., & Robbins, J. (1996). Thermal application reduces the duration of stage transition in dysphagia after stroke. *Dysphagia, 11,* 225–233.

Sackett, D. L., Straus, S. E., Richardson, W. S., Rosenberg, W., & Haynes, R. B. (2000). *Evidence-based medicine: How to practice and teach EBM* (2nd ed.). Edinburgh, United Kingdom: Churchill Livingstone.

*Sciortino, K., Liss, J. M., Case, J. L., Gerritsen, K. G., & Katz, R. C. (2003). Effects of mechanical, cold, gustatory, and combined stimulation to the human anterior faucial pillars. *Dysphagia, 18,* 16–26.

*Selinger, M., Prescott, T. E., & McKinley, R. (1990). The efficacy of thermal stimulation: A case study. *Rocky Mountain Journal of Communication Disorders, 8,* 21–23.

*Selley, W. G. (1985). Swallowing difficulties in stroke patients: A new treatment. *Age and Ageing, 14,* 361–365.

*Shaker, R., Easterling, C., Kern, M., Nitschke, T., Massey, B., Daniels, S., … Dikeman, K. (2002). Rehabilitation of swallowing by exercise in tube-fed patients with pharyngeal dysphagia secondary to abnormal UES opening. *Gastroenterology, 122,* 1314–1321.

*Shaker, R., Kern, M., Bardan, E., Taylor, A., Stewart, E. T., Hoffmann, R. G., … Bonnevier, J. (1997). Augmentation of deglutitive upper esophageal sphincter opening in the elderly by exercise. *American Journal of Physiology: Gastrointestinal and Liver Physiology, 272,* G1518–G1522.

Solomon, N. P., Lorell, D. M., Robin, D. A., Rodnitzky, R. L., & Luschei, E. S. (1995). Tongue strength and endurance in mild to moderate Parkinson's disease. *Journal of Medical Speech-Language Pathology, 3,* 15-26.

Thompson, E. C., Murdoch, B. E., & Stokes, P. D. (1995). Tongue function in subjects with upper motor neuron type dysarthria following cerebrovascular accident. *Journal of Medical Speech-Language Pathology, 3,* 27–40.

*Tzakis, M. G., Kiliaridis, S., & Carlsson, G. E. (1989). Effect of chewing training on masticatory efficiency. *Acta Odontologica Scandinavica, 47,* 355–360.

Wilkins, T., Gillies, R., Thomas, A., & Wagner, P. (2007). The prevalence of dysphagia in primary care patients: A HamesNet Research Network study. *The Journal of the American Board of Family Medicine, 20,* 144–150.

Appendix A

Summary of Swallowing Physiology (Question 1) Exploratory Studies

Citation	*N*	Age (years)	Gender	Medical and/or SLP diagnosis as reported in article	Intervention	Treatment schedule and amount	Outcome measure(s)	Significance	Quality marker score
Ali et al. (1996)	14	40–74, *M* = 59	NR	None	Swallowing was examined under 4 conditions with 2 different volumes (2 ml and 20 ml): No stimulation Cold stimulation Topical anesthesia to anterior tonsillar pillars Cold stimulation following topical anesthesia to anterior tonsillar pillars	NR	Videoradiography and manometry to measure:		3/7
							Oral transit time all conditions and volumes	*ns*	
							Pharyngeal transit time all conditions and volumes	*ns*	
							Pharyngeal clearance time with cold stimulation		
							Volume effect	$p = .047$	
							Cold effect	*ns*	
							Volume/cold interaction	*ns*	
							Pharyngeal clearance time with anesthesia		
							Volume effect	$p = .009$	
							Anesthesia effect	$p = .002$	
							Volume/anesthesia effect	*ns*	
Basar et al. (2003)	1	26	M	Mild cerebral palsy and dysphagia	Innsbruck Sensorimotor Activator and Regulator—oral motor therapy appliance	NR	Functional Feeding Assessment Scale	NR	2/7
Bove et al. (1998)	14	24–50, *M* = 37	7 M, 7 F	None	**Experiment 1:** Chilled laryngeal	**Experiment 1:** Stimulation was	Time taken to swallow 11 times		4/7

					mirror was applied bilaterally to the base of the tonsillar arch compared to same stimulation applied with mirror warmed to 37 °C. **Experiment 2:** Participants held 30 ml of chilled water in mouth compared to water warmed to 37 °C.	applied for 2 s. **Experiment 2:** Stimulation was applied for 3 s.	Experiment 1 Experiment 2	*ns* *ns*	
de Lama Lazzara et al. (1986)	25	NR	15 M, 10 F	Neurological impairment with delay in the trigger of swallow reflex	Thermal stimulation	NR	Sensitized vs. nonsensitized swallows in: Pharyngeal transit time—liquid Pharyngeal transit time—paste Total transit time—liquid Total transit time—paste	 *ns* $p = .0015$ *ns* $p = .0252$	3/7
Hagg & Larsson (2004)	7	48–84	6 M, 1 F	>6 months post-CVA with persistent complaints of dysphagia	Motor and sensory stimulation composed of body regulation, orofacial regulation, oral stimulating plate application, and velopharyngeal closure training	All treatments were applied once a week for 5 weeks. Additionally, palatal plate stimulation, orofacial regulation, and velopharyngeal closure exercises were also performed 2–3 times/day.	VFSS and 4-point severity rating scale of: Bolus control Oral retention Epiglottic closure Retention in vallecula Retention in pyriform sinuses Wrong-way swallowing Cough at swallowing	 *ns* *ns* *ns* *ns* *ns* *ns* *ns*	3/7
Hahn & Hahn (1992)	98	6–57	NR	History of tongue thrust	Myofunctional therapy	NR	Clinical observation of swallowing pattern	NR	0/7
Kaatzke-McDonald et al. (1996)	10	21–37	10 F	None	Thermal, chemical, mechanical, and feigned stimulation applied	Stimulation was applied for 5 s with 3-min intervals between.	Latency of swallow Feigned stimulation Touch stimulation	 *ns* *ns*	3/7

					separately and in combination to faucial pillars		Cold stimulation	$p < .05$	
							Chemical stimulation	*ns*	
							Chemical stimulation vs. feigned stimulation	$p < .05$	
							Chemical plus tactile plus cold stimulation	*ns*	
							Number of swallows evoked		
							Feigned stimulation	*ns*	
							Touch stimulation	*ns*	
							Cold stimulation compared to feigned stimulation	$p < .001$	
							Chemical stimulation compared to feigned stimulation	$p < .0001$	
							Warm chemicals elicited more swallows than chemical plus tactile plus cold stimulation	$p < .01$	
Kikutani et al. (2006)	14	Intervention group: *M* = 84.6 Control group: *M* = 87	3 M, 11 F	Undernourished elderly	**Intervention group**: Nutritional supplements plus oral functional training consisting of voluntary and automatic movements of muscle groups in the oral cavity and perioral region **Control group**: Nutritional supplements only	Duration of treatment was 4 months. Frequency and intensity were not reported.	Water swallow test	NR	2/8
Robbins et al. (2005)	10	70–89	4 M, 6 F	None	Lingual exercise program: Participants compressed an air-filled bulb between the tongue and hard palate and received biofeedback regarding performance.	30 repetitions of the exercise, 3 times/day, 3 days/week for 8 weeks	Swallowing pressures		4/7
							3-ml effortful	$p = .001$	
							3-ml liquid	*ns*	
							10-ml liquid	$p = .04$	
							3-ml semisolid	$p = .01$	
							8-point Penetration-Aspiration Scale	*ns*	

Robbins et al. (2007)	10	51–90, *M*= 69.7	5 M, 5 F	Ischemic stroke and dysphagia	Lingual exercise program using Iowa Oral Performance Instrument	Exercises were performed 3 times/day, 3 days/week for 8 weeks.	**Swallowing pressures** Of the 11 measures taken, 3 were significant: 10-ml liquid *p* = .03 3-ml liquid *p* = .004 Semisolid – *p* = .02 **Penetration-Aspiration Scale** Of the 4 different types of swallows measured, 2 were significant: 3-ml thin liquid *p* = .005 10-ml liquid *p* = .003 **Bolus flow parameters: durational measures** Of the 88 measures taken, 3 were significant: Oral transit duration, 3-ml liquid *p* = .036 Pharyngeal response duration, 10-ml liquid *p* = .024 Pharyngeal response duration, 3-ml liquid *p* = .02 **Oropharyngeal residue measures** Of the 12 overall residue measures, 4 were significant: 3 ml effortful *p* = .02 10-ml liquid *p* = .02 3-ml liquid *p* = .01 Average *p* = .04	3/7
Rosenbek et al. (1996)	23	54–81, *M* = 67.3	22 M, 1 F	CVA and dysphagia	Thermal application of chilled size 00 laryngeal mirror to anterior faucial pillars	10 treatment trials (a trial was defined as 6 strokes, 3 to each faucial pillar)	Duration of stage transition *p* = .046 Total swallow duration *p* = .005	4/7

Sciortino et al. (2003)	14	21–80, *M* = 47.75	6 M, 8 F	None	Each participant's swallow was studied under the following 8 conditions: 1. No stimulation 2. Cold stimulation 3. Gustatory stimulation 4. Mechanical stimulation 5. Mechanical plus cold stimulation 6. Mechanical plus gustatory stimulation 7. Cold plus gustatory stimulation 8. Mechanical plus cold plus gustatory stimulation	Each participant was administered the 8 different conditions 4 times.	Surface EMG measurement of latency to first swallow-specific activity		3/7
							No stimulation compared to mechanical plus cold plus gustatory stimulation	$p = .045$	
							All other pairwise results	*ns*	
							Duration of submental EMG activity		
							Among and across all stimulation conditions	*ns*	
Selinger et al. (1990)	1	56	M	Brainstem CVA and dysphagia	Thermal stimulation	5–7 trials/treatment. Treatment was administered twice on first day and then 3 times/day on the subsequent 8 days.	Modified barium swallow procedure to determine aspiration. Following treatment, individual continued to aspirate.	NR	1/7
Selley (1985)	170	Exact range not reported; described as ranging from <50 to 80+.	107 M, 63 F	Stroke with dysphagia and drooling	Palatal training appliance	Participants were instructed to wear the appliance during the day and remove it at night. Duration of treatment not reported.	Patient report of cessation of drooling while awake and the ability to swallow food and fluids without choking	NR	0/7
Shaker et al. (1997)	31	62–91	NR	None	**Intervention:** Sustained and consecutive head raisings in supine. **Control:** Sustained and repetitive fist clenching	3 times/day for 6 weeks	VFSS to determine within-group differences in:		3/8
							Narrowest area of UES at maximum opening diameter		
							Intervention group	*ns*	

							Control group	*ns*	
							Anteroposterior diameter of maximum UES opening:		
							Intervention group	$p < .05$	
							Control group	*ns*	
							UES cross-sectional area		
							Intervention group	$p < .05$	
							Control group	*ns*	
							Maximum lateral diameter of narrowest area of UES		
							Intervention group	*ns*	
							Control group	*ns*	
							Maximum superior and anterior hyoid excursion		
							Intervention group	*ns*	
							Control group	*ns*	
							Maximum superior laryngeal excursion		
							Intervention group	*ns*	
							Control group	*ns*	
							Duration of UES opening		
							Intervention group	*ns*	
							Control group	*ns*	
							Maximum anterior excursion of larynx		
							Intervention group	$p < .05$	
							Control group	*ns*	
							Intrabolus hypopharyngeal pressure		
							Intervention group	$p < .05$	
							Control group	*ns*	
Tzakis et al. (1989)	25	20–31	11 M, 14 F	None	**Intervention:** Chewing high-resistance gum **Control:** None	1 hr daily for 28 days	Masticatory efficiency		3/8
							Intervention group		
							Decrease immediately following 30-min	$p < .001$	

chewing session before initiation of training	
Decrease immediately following 30-min chewing session at completion of training	*p* < .001
Pre- vs. posttraining	*ns*
Control group	
All times	*ns*
Time of 10 chewing cycles	
Intervention group	
Decrease immediately following 30-min chewing session before initiation of training	*p* = .001
Decrease immediately following 30-min chewing session at completion of training	*p* < .01
Pre vs. posttraining	*ns*
Control group	
All times	*ns*

Note: SLP= speech-language pathologist; NR = not reported or calculable; CVA= cerebrovascular accident; VFSS = videofluoroscopic swallowing study; EMG = electromyography; UES = upper esophageal sphincter.

Appendix B

Summary of Functional Swallowing Outcomes (Question 3) Exploratory Studies

Citation	*N*	Age (years)	Gender	Medical and/or SLP diagnosis as reported in article	Intervention	Treatment schedule and amount	Outcome measure(s)	Significance	Quality marker score
Beurskens & Heymans (2004)	155	6–85, *M* = 42	61 M, 94 F	Peripheral facial nerve paresis	Mime therapy—automassage of face and neck, kneading and muscle stretching as well as breathing and relaxation exercises	On average, participants received 10 treatment sessions once/week for 45 min. Participants were asked to do daily homework.	Patient report of difficulties eating (8-point scale) Patient report of difficulties drinking (5-point scale)	$p \leq .05$ $p \leq .05$	1/7
Hagg & Larsson (2004)	7	48–84	6 M, 1 F	>6 months post-CVA with persistent complaints of dysphagia	Motor and sensory stimulation composed of body regulation, orofacial regulation, palatal plate application, and velopharyngeal closure training	All treatments were applied 1 time/week for 5 weeks. Additionally, palatal plate stimulation, orofacial regulation, and velopharyngeal closure exercises were also performed 2–3 times/day.	Patient self-assessment regarding the impact of dysphagia on his or her life situation	NR	1/7
Kikutani et al. (2006)	14	Intervention group: *M* = 84.6 Control group: *M* = 87	3 M, 11 F	Undernourished elderly	**Intervention group:** Nutritional supplements plus oral functional training consisting of voluntary and automatic movements of muscle groups in the oral cavity and perioral region. **Control group:** Nutritional supplements only	Duration of treatment was 4 months. Frequency and intensity were not reported.	Weight gain: Intervention group Weight gain: Control group	$p < .05$ *ns*	5/8

Neumann et al. (1995)	58	22–84, *Mdn* = 57	32 M, 26 F	Dysphagia due to neurological disorder	Indirect therapy—perioral and oral stimulation, thermal tactile stimulation, isotonic exercises, and isometric exercises Direct therapy—compensatory strategies during swallowing, supraglottic swallowing, and Mendelsohn maneuver.	5 days/week for 45 min	Total oral feeding—participants who received indirect therapy only compared to those who received a combination of indirect and direct therapy	*ns*	1/7
Robbins et al. (2007)	10	51–90, *M* = 69.7	5 M, 5 F	Ischemic stroke and dysphagia	Lingual exercise program using Iowa Oral Performance Instrument	Exercises were performed 3times/day, 3 days/week for 8 weeks.	SWAL-QOL 3 of 11 subscales showed significant changes: Fatigue Communication Mental	 *p* = .047 *p* = .026 *p* = .022	3/7

Appendix C

Summary of Drooling/Secretion Management (Question 4) Exploratory Study

Citation	*N*	Age	Gender	Medical and/or SLP diagnosis as reported in article	Intervention	Treatment schedule and amount	Outcome measure(s)	Significance	Quality marker score
Selley (1985)	170	NR	107 M, 63 F	Dysphagia or drooling	Palatal training appliance	Participants wore appliance during the day. Schedule or length of treatment was not stated.	Patient report of cessation of drooling and ability to swallow food and liquid without choking	NR	0/7