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Evidence-based systematic review: Oropharyngeal dysphagia behavioral treatments. Part II—Impact of dysphagia treatment on normal swallow function

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Abstract—This article is the second in a series of evidence-based systematic reviews. Data reported cover the impact of dysphagia behavioral interventions on swallow physiology in healthy adults. The behavioral treatments investigated were three postural interventions—side lying, chin tuck, and head rotation—and four swallowing maneuvers—effortful swallow, the Mendelsohn maneuver, supraglottic swallow, and super-supraglottic swallow. A systematic search of the dysphagia literature was conducted in 14 electronic databases. Seventeen studies meeting the inclusion criteria were evaluated for methodological quality with the American Speech-Language-Hearing Association's levels-of-evidence scheme and were characterized by research stage (i.e., exploratory, efficacy, effectiveness, cost-benefit/public policy research). Effect sizes were calculated when possible. All studies were exploratory research ranging from two to five of seven possible quality markers. The majority of studies (8 of 17) investigated effortful swallow. Three studies examined the Mendelsohn maneuver, chin tuck, supraglottic swallow, and super-supraglottic swallow and two studies addressed head rotation. No study addressed side lying. For non-disordered populations, the existing evidence demonstrates differential effects of postural changes and maneuvers on swallowing physiology. Some effects reinforced existing recommendations for the applications of the interventions, while others suggested new ways that the treatments may impact swallow function. Avenues for future research are suggested.

Key words: chin-tuck posture, dysphagia, effortful swallow maneuver, evidence-based practice, evidence-based systematic review, head-rotation posture, Mendelsohn maneuver, rehabilitation, side-lying posture, super-supraglottic swallow maneuver, supraglottic swallow maneuver, treatment.

INTRODUCTION

Swallowing dysfunction, or dysphagia, can occur in adult patients as a result of significant primary illnesses, including cerebrovascular accidents, neurodegenerative disorders, head and neck cancer, or head injury [1–3]. Treatment to improve disordered oropharyngeal deglutition has traditionally centered on behavioral interventions, with the intended purpose of facilitating safe and efficient

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Abbreviations: ASHA = American Speech-Language-Hearing Association, BOT = base of the tongue, ES = effect size, N-CEP = National Center for Evidence-Based Practice in Communication Disorders, PPW = posterior pharyngeal wall, SM = submental, UES = upper esophageal sphincter, VA = Department of Veterans Affairs.

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oral feeding. These behavioral therapeutic approaches have been used clinically, primarily by speech-language pathologists trained in dysphagia management [4]. They include posturing of the head and neck, physical maneuvers altering oral and pharyngeal physiology, tactile and electrical stimulation, oral and facial exercises, and diet modifications [5]. To date, a number of published guidelines and evidence-based systematic reviews have focused on dysphagia within various populations and treatment settings [6–9]. These primarily address the need for dysphagia evaluation and dietary management with little emphasis placed on behavioral interventions.

In 1972, Larsen was the first to introduce the notion of behavioral interventions to improve swallow function, describing the use of "neck-flexed postures" and "breath-holding maneuvers" to facilitate a safe, functional swallow [10]. In the 1980s, the investigation of these techniques expanded to other postural interventions and swallowing maneuvers. Currently, a body of literature exists examining the physiological effects of many of these swallowing techniques among healthy adults as well as among various patient populations [5,11].

According to a five-phase model of clinical outcomes developed by Robey [12], before the introduction of interventions as treatments for specific patient groups, it is necessary to establish the existence of an intervention effect and determine whether that effect is sufficient to warrant further testing. Establishing such an effect begins with defining the physiological changes that occur during the treatment; this identifies the ability of the treatment to modify function and establishes a knowledge base from which to formulate hypotheses regarding the potential effects of the treatment on specific types of disorders. Physiological changes can include changes in oral or pharyngeal pressures, duration and timing of swallow events, structural movement or displacement, and muscle activation.

The American Speech-Language-Hearing Association's (ASHA's) National Center for Evidence-Based Practice in Communication Disorders (N-CEP), in collaboration with the Department of Veterans Affairs (VA), embarked on a series of systematic reviews to examine the current state of the evidence on behavioral swallowing treatments. The current review focuses on behavioral swallowing treatments (head and neck postures and swallowing maneuvers) with nondisordered populations (healthy adults). This body of literature examines physiological changes imposed by the treatments under examination. Subsequent reviews reported in this series focus on studies examining these same interventions in populations with neurological disorders (e.g., brain injury, stroke; see Ashford et al., this issue, Part III, p. 195) and populations with structural disorders (e.g., head and neck cancer; see McCabe et al., this issue, Part IV, p. 205).

The first step in the process was to determine the clinical question addressed by studies that targeted behavioral treatments including postures and maneuvers. Postures were operationally defined as a repositioning of the body, head, and/or neck before the onset of the pharyngeal phase of the swallow, with maintenance of the position until the swallow was completed. Postures studied included side lying, chin tuck, and head rotation. Maneuvers were defined as movement of the oral, pharyngeal, or laryngeal structures that occur before or during the pharyngeal phase of the swallow and are intended to increase swallow force or alter airway protection mechanisms. Maneuvers studied included effortful swallow, the Mendelsohn maneuver, supraglottic swallow, and super-supraglottic swallow. The clinical question under review was, What is the effect of dysphagia behavioral interventions (i.e., side-lying, chin-tuck, or head-rotation postures; effortful swallow, Mendelsohn, supraglottic swallow, or super-supraglottic swallow maneuvers) on the swallowing physiology of healthy adults? Physiological effects were defined as alterations in the pressures, timings, displacements, or muscle activations achieved during a posture or maneuver.

METHODS

A systematic search of the dysphagia literature was conducted from March 2007 to April 2008 to examine postural and/or maneuver-based behavioral swallow interventions. A detailed account of the systematic search of the dysphagia literature and the inclusion/exclusion criteria is provided in the preceding article in this series (Frymark et al., this issue, Part I, p. 175).

The initial results, which included disordered populations, yielded a total of 219 citations. For this review, findings were narrowed to include only nondisordered populations, with 22 studies meeting preliminary inclusion criteria. Two of the authors (TF and TS) independently reviewed each citation to determine initial inclusion. The full author panel further rejected 5 studies upon review of the full text, leaving a total of 17 studies in the final analysis.

Accepted studies were appraised for methodological quality with use of ASHA's levels-of-evidence scheme [13]. Two authors (TF and TS), blinded from each other's results, appraised each study independently and determined a final quality-marker score. Discrepancies in ratings between authors were resolved via consensus by all authors. Each study was evaluated on a maximum of eight quality indicators including study design, blinding, sampling/allocation, group/participant comparability, outcomes, significance, precision, and intention to treat (when applicable) and was placed in one of four stages of research: exploratory, efficacy, effectiveness, or cost-benefit/public policy research (see Table 1 and Figure 2 of Frymark et al., this issue, Part I, p. 175). Studies were awarded one point per indicator when that indicator met criteria for the highest quality level. The eighth marker (intention to treat) was not applicable, because the current review is focused on healthy, nondisordered swallowing; therefore, the highest possible quality score was 7 points. A final synthesis of the included literature was reported based on the study quality-marker score and the corresponding stage of research. Effect sizes (ESs) were calculated with use of Cohen's *d* for outcome measures when possible [14].

RESULTS

Seventeen studies met the inclusion/exclusion criteria and were included in the review [15–31]. Interjudge agreement on inclusion/exclusion criteria was 90 percent. Study information, including participant demographics and intervention variables, are displayed in **Table 1**. Study sample sizes ranged between 4 and 64 adult participants (18–94 years old) with nondisordered swallowing. Among the 12 studies that reported sex, 53 percent of the participants were male and 47 percent were female.

Five studies provided data that addressed swallowing postures. Of those five studies, three investigated the chin tuck [16–17,31] and two examined the head rotation [25,27]. No studies were found that investigated side lying. Thirteen studies provided data addressing swallowing maneuvers, with the majority (62%, 8 of 13) investigating the effortful swallow intervention [16,19–22,24,28–29]. Three studies examined the Mendelsohn maneuver [15,18,23], three examined the supraglottic swallow [15–16,26], and three examined the super-supraglottic swallow [15,26,30].

Table 2 displays the quality-marker ratings for each study. Sixty-five percent of studies (11 of 17) received a quality-marker score of 3 or below. The highest quality score was 5 and was attained by Hind et al. [19] and Huckabee et al. [21]. All included studies were part of a case series or case study design and were in the exploratory stage of research. All studies adequately described their participants, with the majority recruiting participants by convenience sampling procedures. A total of 14 of 17 studies (82%) provided both probability and ES data, and 8 of 17 studies (47%) used valid outcome measures. Only Huckabee et al. reported blinding of assessors [21].

The physiological variables that were addressed by these studies fell into one of four categories: oral or pharyngeal pressures, duration and timing of swallow events, structural movement or displacement, and muscle activation. These variables are summarized in the tables in the **Appendix** (available online only). Where possible, ESs [14] are reported for the physiological variables by technique and ranged from smaller ESs (0.34) to very large ESs (5.23). The majority of ESs were modest and ranged from 0.50 to 1.25.

DISCUSSION

This systematic review examined the current state of the evidence on the effects of seven dysphagia behavioral interventions on swallowing physiology for healthy subjects. A systematic search of the peer-reviewed literature published between 1985 and 2008 yielded 17 studies that met predetermined inclusion criteria. Of those studies, 5 examined postural techniques [16–17,25,27,31] and 13 examined swallow maneuvers [15–16,18–24,26,28–30]. The side-lying posture was not included in any of the studies on nondisordered swallowing.

All studies included were in the exploratory stage of research, which is appropriate given the nondisordered population, and the general aim of these studies was to investigate the physiological variables that were potentially affected by each technique. Exploratory studies, by definition, include treatment approaches that are developed and assessed in the context of whether they show promise of efficacy. For a study to reach the level of an efficacy study, the treatment of interest should be subjected to ideal, highly controlled conditions in which specific outcomes are assessed pre- and posttreatment; the

Table 1.
Participant and intervention characteristics for 17 studies included in review of oropharyngeal dysphagia behavioral treatments.

Study	*N*	Age (Range &/or Mean)	Sex		Intervention
			Male	Female	
Bodén et al., 2006 [1]	10	34–39 (36.1)	5	5	Mendelsohn maneuver, supraglottic swallow, super-supraglottic swallow
Bülow et al., 1999 [2]	8	25–64 (41)	4	4	Chin tuck, effortful swallow, supraglottic swallow
Castell et al., 1993 [3]	9	24–55 (31)	6	3	Chin tuck
Ding et al., 2002 [4]	20	18–38 (23.5)	10	10	Mendelsohn maneuver
Hind et al., 2001 [5]	64	45–93 (69.6)	NR	NR	Effortful swallow
Hiss & Huckabee, 2005 [6]	18	27.9	9	9	Effortful swallow
Huckabee et al., 2005 [7]	22	27.9	11	11	Effortful swallow
Huckabee & Steele, 2006 [8]	20	20–35	0	20	Effortful swallow
Kahrilas et al., 1991 [9]	8	22–28	8	0	Mendelsohn maneuver
Lever et al., 2007 [10]	20	20–25 (25.2)	10	10	Effortful swallow
Logemann et al., 1989 [11]	6	23–58	NR	NR	Head rotation
Ohmae et al., 1996 [12]	8	20–28	8	0	Supraglottic swallow, super-supraglottic swallow
Ohmae et al., 1998 [13]	7	20–28	7	0	Head rotation
Pouderoux & Kahrilas, 1995 [14]	8	21–35	NR	NR	Effortful swallow
Steele & Huckabee, 2007 [15]	20	20–35	NR	NR	Effortful swallow
Van Daele et al., 2005 [16]	4	NR	NR	NR	Super-supraglottic swallow
Welch et al., 1993 [17]	30	30–94	17	13	Chin tuck

1. Bodén K, Hallgren A, Witt Hedström H. Effects of three different swallow maneuvers analyzed by videomanometry. Acta Radiol. 2006;47(7):628–33. [PMID: 16950694] DOI:10.1080/02841850600774043
2. Bülow M, Olsson R, Ekberg O. Videomanometric analysis of supraglottic swallow, effortful swallow, and chin tuck in healthy volunteers. Dysphagia. 1999; 14(2):67–72. [PMID: 10028035] DOI:10.1007/PL00009589
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9. Kahrilas PJ, Logemann JA, Krugler C, Flanagan E. Volitional augmentation of upper esophageal sphincter opening during swallowing. Am J Physiol. 1991; 260(3 Pt 1):G450–56. [PMID: 2003609]
10. Lever TE, Cox KT, Holbert D, Shahrier M, Hough M, Kelley-Salamon K. The effect of an effortful swallow on the normal esophagus. Dysphagia. 2007; 22(4):312–25. [PMID: 17694407] DOI:10.1007/s00455-007-9107-2
11. Logemann JA, Kahrilas PJ, Kobara M, Vakil NB. The benefit of head rotation on pharyngoesophageal dysphagia. Arch Phys Med Rehabil. 1989;70(10):767–71. [PMID: 2802957]
12. Ohmae Y, Logemann JA, Kaiser P, Hanson DG, Kahrilas PJ. Effects of two breath-holding maneuvers on oropharyngeal swallow. Ann Otol Rhinol Laryngol. 1996;105(2):123–31. [PMID: 8659933]
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15. Steele CM. Huckabee ML. The influence of orolingual pressure on the timing of pharyngeal pressure events. Dysphagia. 2007;22(1):30–36. [PMID: 17024546] DOI:10.1007/s00455-006-9037-4
16. Van Daele DJ, McCulloch TM, Palmer PM, Langmore SE. Timing of glottic closure during swallowing: a combined electromyographic and endoscopic analysis. Ann Otol Rhinol Laryngol. 2005;114(6):478–87. [PMID: 16042106]
17. Welch MV, Logemann JA, Rademaker AW, Kahrilas PJ. Changes in pharyngeal dimensions effected by chin tuck. Arch Phys Med Rehabil. 1993;74(2):178–81. [PMID: 8431103]

NR = not reported.

Table 2.
Methodological quality and quality-marker score for studies included in review of oropharyngeal dysphagia behavioral treatments.

Study	Design	Assessor Blinding	Random Sampling Described	Subjects Comparable/ Described	Valid Outcome Measure	Significance	Precision	Intention to Treat	Quality-Marker Score
Bodén et al., 2006 [1]	Case series	No	No	Yes	No	Yes	Yes	NA	3/7
Bülow et al., 1999 [2]	Case series	No	No	Yes	No	Yes	Yes	NA	3/7
Castell et al., 1993 [3]	Case series	No	No	Yes	Yes	Yes	Yes	NA	4/7
Ding et al., 2002 [4]	Case study	No	No	Yes	Yes	Yes	Yes	NA	4/7
Hind et al., 2001 [5]	Case series	No	Yes	Yes	Yes	Yes	Yes	NA	5/7
Hiss & Huckabee, 2005 [6]	Case series	No	No	Yes	No	Yes	Yes	NA	3/7
Huckabee et al., 2005 [7]	Case series	Yes	No	Yes	Yes	Yes	Yes	NA	5/7
Huckabee & Steele, 2006 [8]	Case series	No	No	Yes	No	Yes	Yes	NA	3/7
Kahrilas et al., 1991 [9]	Case series	No	No	Yes	No	Yes	Yes	NA	3/7
Lever et al., 2007 [10]	Case series	No	No	Yes	Yes	Yes	No	NA	3/7
Logemann et al., 1989 [11]	Case series	No	No	Yes	Yes	Yes	Yes	NA	4/7
Ohmae et al., 1996 [12]	Case series	No	No	Yes	No	Yes	Yes	NA	3/7
Ohmae et al., 1998 [13]	Case series	No	No	Yes	No	Yes	Yes	NA	3/7
Pouderoux & Kahrilas, 1995 [14]	Case series	No	No	Yes	No	Yes	Yes	NA	3/7
Steele & Huckabee, 2007 [15]	Case series	No	No	Yes	No	Yes	No	NA	2/7
Van Daele et al., 2005 [16]	Case series	No	No	Yes	Yes	No	No	NA	2/7
Welch et al., 1993 [17]	Case series	No	No	Yes	Yes	Yes	Yes	NA	4/7

1. Bodén K, Hallgren A, Witt Hedström H. Effects of three different swallow maneuvers analyzed by videomanometry. Acta Radiol. 2006;47(7):628–33. [PMID: 16950694] DOI:10.1080/02841850600774043
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4. Ding R, Larson CR, Logemann JA, Rademaker AW. Surface electromyographic and electroglottographic studies in normal subjects under two swallow conditions: Normal and during the Mendelsohn maneuver. Dysphagia. 2002;17(1):1–12. [PMID: 11820381] DOI:10.1007/s00455-001-0095-3
5. Hind JA, Nicosia MA, Roecker EB, Carnes ML, Robbins J. Comparison of effortful and noneffortful swallows in healthy middle-aged and older adults. Arch Phys Med Rehabil. 2001;82(12):1661–65. [PMID: 11733879] DOI:10.1053/apmr.2001.28006]
6. Hiss SG, Huckabee ML. Timing of pharyngeal and upper esophageal sphincter pressures as a function of normal and effortful swallowing in young healthy adults. Dysphagia. 2005;20(2):149–56. [PMID: 16172825] DOI:10.1007/s00455-005-0008-y
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17. Welch MV, Logemann JA, Rademaker AW, Kahrilas PJ. Changes in pharyngeal dimensions effected by chin tuck. Arch Phys Med Rehabil. 1993;74(2):178–81. [PMID: 8431103]

NA = not applicable.

hypotheses of these studies should be based on exploratory studies that indicated the mechanistic potential of the intervention to treat a disorder. Thus, the studies included in this review are essential to building the rationale and evidence base for the use of these treatment options for dysphagia. We will discuss each intervention individually to elucidate the physiological changes it imposes on the swallow mechanism. For a detailed summary of physiological findings, including available ESs, see the **Appendix**.

Postural Techniques

Chin Tuck

Three studies investigating the chin tuck met inclusionary criteria and were included in the review [16–17,31]. The chin tuck, or head flexion, is a posture used during swallowing whereby the head is tilted downward (toward the chest) as much as possible without being extended forward [4,31]. Physiological variables that have been studied in healthy, nondisordered participants using the chin tuck include pressures in the pharynx and upper esophageal sphincter (UES) during the swallow, durations and timings of swallowing events, and displacement of anatomical structures during swallowing. Those measures found to be significantly changed ($p < 0.05$) by the chin tuck versus a normal swallow include pharyngeal contraction pressure, the duration of pharyngeal contraction pressure, the larynx-to-hyoid bone distance, the hyoid-to-mandible distance before the swallow, the angle between the mandible and the posterior pharyngeal wall (PPW), the angle between the epiglottis and the anterior wall of the trachea, the distance from the epiglottis to the PPW, and the width of the airway entrance (see **Appendix**). Interestingly, of the two studies that measured pharyngeal contraction pressure and pharyngeal contraction durations as dependent variables, only one reported a significant difference for these measures [16–17]. Specifically, Bülow and colleagues reported increases in pharyngeal contraction pressure and in pharyngeal contraction duration during the chin tuck versus normal swallowing [16]. Effects of the chin tuck on these variables were not found to be significantly different by Castell and colleagues [17]. These conflicting findings may be due to the methodological differences between the studies. For example, Bülow and colleagues used 10 mL water boluses, while Castell and colleagues used 5 mL. Additionally, the chin tuck itself differed between these studies; the Bülow et al. study simply instructed participants to "tuck the chin downward" [16, p. 68], while the Castell et al. study quantitatively measured two different head-flexion, or chin-tuck, positions [17]. Therefore, one should be cautious when interpreting these findings (significance vs nonsignificance of pharyngeal contraction pressure and duration), since they are clearly sensitive to slight differences in measurement and may not be important changes to consider when the chin tuck is used with specific types of oropharyngeal dysphagia.

An ES was calculable for four of the eight variables found to be significantly different during the chin tuck versus normal swallowing. These variables included the angle between the mandible and the PPW, the angle between the epiglottis and the anterior wall of the trachea, the distance from the epiglottis to the PPW, and the width of the airway entrance, all of which were decreased for the chin tuck versus normal swallowing. The ESs ranged from 0.60 to 1.14, indicating a moderate effect for the chin tuck on those variables [14]. Collectively, evidence with calculable ESs indicates that the chin tuck changes the anatomic relationships between structures involved in swallowing before the swallow and narrows the width of the airway entrance before the swallow. Therefore, the potential of the chin tuck to mechanistically treat certain aspects of swallowing disorders is established and investigation into its efficacious value warranted.

Head Rotation

Two studies included in the review investigated head rotation in healthy, nondisordered swallowing [25,27]. Head rotation is achieved by simply rotating the head to the left or right during the swallow; in disordered swallowing, the head is rotated to the weakened side [4]. Because these two studies examined healthy subjects, instead of rotating to a weakened side, subjects were asked to rotate the head toward or away from a manometric sensor located in the pharynx or simply to each side for measurement [25,27]. When compared with a neutral head position, rotating the head to the left or right increased pharyngeal contraction pressure at the level of the valleculae and pyriform sinuses on the side of rotation, decreased UES resting pressure on the side opposite rotation, increased duration from peak pharyngeal pressure in the pyriform sinuses to the end of UES relaxation, and increased UES anterior-posterior opening diameter (see **Appendix**). These findings are accompanied by unilateral bolus flow to the side opposite head rotation.

Thus, these studies have laid a foundation for use of the head rotation as a compensatory mechanism for dysphagia characterized by unilateral weakness or possibly by increased tone and resistance to opening at the UES [25,27]. Specifically, rotating the head to the weak side would result in redirected bolus flow through the pyriform sinus on the strong side. This redirection would result in a concurrent decrease in UES resistance to bolus flow and prolongation of UES opening, allowing bolus material to flow in a less obstructed manner through the UES and providing more time to clear all bolus material from the pharynx [27].

Side Lying

The existing rational for use of the side-lying technique is that lying down will hold residual bolus material to the pharyngeal walls instead of allowing it to drop into the airway, which may more readily occur as a result of gravity in an upright position [4]. Logemann recommends the use of side lying when pharyngeal contraction is reduced such that residue is observed throughout the pharynx [4]. The side-lying posture was not included in any of these studies on healthy swallowing; therefore, the physiological basis of this posture bears no support from exploratory research.

Maneuvers

Mendelsohn Maneuver

Three studies included in the review investigated the effect of the Mendelsohn maneuver on swallowing physiology in healthy, nondisordered swallowing [15,18,23]. Execution of the Mendelsohn maneuver requires the user to maintain hyolaryngeal elevation during swallowing for a count of at least 2 seconds. The goal of the maneuver is to prolong UES opening, and it was originally designed for dysphagia characterized by decreased laryngeal movement [4]. Variables for which significant differences were found (vs normal swallows) included peak pharyngeal pressure, UES contraction pressure, UES opening duration, duration of hyoid-UES separation, duration of laryngeal elevation, bolus transit time, hyoid excursion, distance between the hyoid bone and the thyroid cartilage, duration of contraction for various muscles, and maximum and mean electromyography amplitude for various muscles (see **Appendix**). Effect size was calculable for peak pharyngeal-contraction pressure, UES peak contraction pressure, duration of UES opening, duration of pharyngeal contraction, and bolus transit time. The measure of peak pharyngeal contraction had the smallest ES (0.45), which is considered to be a modest ES [14]. All other variables had large ESs ranging from 0.84 to 4.29, with the largest found for the measure of peak pharyngeal-contraction duration.

Generally, the durations and amplitudes of pressure, displacements, and muscle activity increased (with the exception of UES pressure and larynx-to-hyoid distance) during the Mendelsohn maneuver. While the maneuver was originally designed to simply increase the duration of UES opening (which it does), it clearly affects other physiological aspects of swallowing, such as airway protection and muscle activation patterns. Thus, further study of the potential occurrence of neural and muscle adaptations as a result of the maneuver is warranted, as are studies examining its potential treatment effect on other manifestations of dysphagia. For example, with increased amplitude and duration of muscle activity observed, its use as a direct swallowing exercise specifically targeting strength and endurance of swallow muscles (submentals [SMs]) may prove to be an appropriate and effective application of the maneuver.

Effortful Swallow

Approximately one-half (8/17) of the studies included in this review examined the effect of the effortful-swallow maneuver in healthy, nondisordered populations [16,19–22,24,28–29]. The effortful swallow requires increased muscle “squeezing” during the swallow; however, the instructions for effortful swallowing vary between studies, with many including directions simply to “swallow hard” and some including more specific instructions, for example, emphasizing tongue-to-palate contact [16,21]. The original goal of the effortful swallow is to maximize posterior base of the tongue (BOT) motion, resulting in improved bolus clearance from the valleculae [4]. The physiological effects of effortful swallowing are somewhat variable, with some disagreement between studies. Measures of pressure during effortful swallowing indicate that lingual pressure and pharyngeal pressures are increased during the maneuver [19,21–22,28], while UES relaxation pressures are decreased [21]. However, Bülow and colleagues found no significant differences for peak pharyngeal-contraction pressures during effortful swallowing [16]. Regarding timing, measures of the duration of lingual, pharyngeal, and UES relaxation pressures increased during effortful swallowing [19–20,29]; Bülow et al. found no significant differences in the duration of pharyngeal contraction pressure or UES relaxation [16].

Analyses of structural displacement for the effortful swallow are also somewhat ambiguous. For example, hyoid movement is reported to increase [19] and decrease [16] in effortful swallowing versus normal swallowing. In each of these studies, the measures were made differently depending on when and where the initial and maximum points of displacement were identified. Measures of durations for displacement increased for effortful swallowing [19], as did the measure of surface electromyography for the SM muscles [22]. Thus, the results that agree indicate that the effortful swallow increases lingual pressures; the duration of lingual, pharyngeal, and UES relaxation pressures; the duration of hyoid and laryngeal displacement; and SM muscle activation. The initial purpose of the maneuver to increase BOT posterior motions is plausible based on these data, and there are other avenues to explore by which the effortful swallow may improve swallow function, including increased force-generating ability of the SM muscles and improved airway protection by prolongation of the time the hyolaryngeal complex is pulled up and forward.

Supraglottic Swallow

Three studies contributed data that address the supraglottic swallow [15–16,26]. Originally designed for dysphagia accompanied by reduced or late vocal fold closure or delayed pharyngeal swallow, the supraglottic swallow requires the user to hold his or her breath before, during, and after the swallow, presumably resulting in increased airway protection [4]. Results of studies included in this review indicate that the supraglottic swallow changes the timing of UES opening, the duration and timing of hyoid excursion and laryngeal closure, and the timing of BOT movement (see **Appendix**). Results for UES contraction pressure and opening duration were inconclusive because the three studies disagreed regarding the existence of significant differences. Methodological and measurement differences likely account for this disagreement. ESs were calculable for nine variables and were modest, ranging from 0.58 to 1.76 [14].

Overall, results of the physiological study of the supraglottic swallow indicate that it does close the vocal folds earlier in the swallow while concurrently prolonging hyolaryngeal excursion [26]. Hence, the original purpose of the technique to treat dysphagia accompanied by reduced or late vocal fold closure is supported by physiological findings. Because of the laryngeal focus of this maneuver, further investigation on its effects on the larynx may be of interest. Cough generation, because of its interdependence on expiratory pressures and laryngeal valving, might be an interesting research avenue; as well, the parameters of sensory stimulation and positive pressure generation within the laryngeal vestibule, glottal, and subglottal regions might reveal further beneficial effects of the supraglottic swallow that were not originally targeted with the technique.

Super-Supraglottic Swallow

Three studies investigated the use of the super-supraglottic swallow [15,26,30]. The super-supraglottic swallow is a more effortful breath-hold maneuver than the supraglottic swallow maneuver and requires completion of the swallow accompanied by a volitional cough [4]. The super-supraglottic swallow is also recommended for patients with dysphagia secondary to reduced closure of the airway entrance [4]. ESs were calculable for 14 variables and ranged from 0.31 to 3.86 [14]. Studies included in this review indicate that the super-supraglottic swallow increased UES relaxation pressure and duration of hyoid excursion and laryngeal movement and decreased time between UES opening and onset of hyoid movement and BOT movement time between UES opening and the onset of vocal fold adduction and laryngeal closure (indicating these airway-protective mechanisms happened earlier in the swallow sequence). Displacement decreased for the hyoid bone and increased for the larynx and the width of UES opening. The duration of UES opening and displacement of the hyoid bone were not significantly different in one study but were different in another [15,26]. Again, methodological differences likely explain these inconsistencies. Like the supraglottic swallow, the super-supraglottic swallow is supported by physiological evidence, suggesting it does alter the timing of airway protection such that the airway is protected earlier in the swallow sequence than during normal swallows. Interestingly, however, the volitional cough, which is included as part of the super-supraglottic swallow, was not investigated in any of these studies; therefore, the effect and effectiveness of a volitional cough immediately following a super-supraglottic swallow for coordination and biomechanics are unknown. Further study is warranted, particularly with regard to the cough component of this maneuver.

CONCLUSIONS

The body of literature in this systematic review collectively indicates that for six of the seven behavioral interventions included, physiological evidence supports existing hypotheses regarding the role of each intervention in treating specific aspects of dysphagia. The ESs these interventions exhibit on many of the physiological variables aid in the identification of clinically significant differences, which may be applied to populations with disorders and therefore are recommended for a level of research beyond the exploratory stage. Additionally, these studies reveal changes to aspects of swallow biomechanics not originally targeted by the maneuvers, which suggests the possibility of new applications for each with regard to dysphagia treatment. Further, inconclusive evidence resulting from either methodological differences or high degrees of variability among healthy subjects along with parameters that have not yet been addressed during execution of these maneuvers, such as their effect on the respiratory or neurologic systems, leave a plethora of research avenues open and recommended for exploration.

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