The Efficacy of Electrical Stimulation Intervention in Treating Adults with Dysphagia: A Systematic Review

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Abstract

Purpose: Dysphagia is a term used for a swallowing disorder resulting from problems with the oral cavity, pharynx, esophagus, or gastroesophageal junction. Dysphagia can have significant impacts on an individual's quality of life and statistics suggest that nearly 15 million adults in the United States present with swallowing disorders. Common medical complications associated with dysphagia are malnutrition, dehydration, aspiration pneumonia, and even death. Traditional dysphagia treatment (TDT) for adults currently consists of diet modification, compensatory strategies involving postural adjustments, and swallowing exercises to strengthen musculature. The objective of this systematic review is to determine whether electrical stimulation (ES) improves swallowing function in adults with dysphagia.

Methodology: Four indexed databases were searched to obtain studies pertaining to the use of ES in dysphagia treatment and its success. Application of inclusionary and exclusionary criteria narrowed the results and relevant studies were selected for this systematic review. Studies were also hand-selected and appraised for validity to ensure minimal bias.

Results: Results of the selected studies revealed varying statistically significant effects of ES as a treatment for adults with dysphagia. However, many studies suggest ES is most effective in producing positive outcomes when coupled with TDT.

Conclusion: The results of the systematic review suggest efficacy of ES is highest when it is used in conjunction with TDT. Studies with statistically significant results reported on only a minor improvement with ES. None of the studies reported negative outcomes related to ES. Additional research is needed to determine overall efficacy of ES as an evidence-based intervention for adults with dysphagia resulting from various etiologies.

Background

Dysphagia is a term used for a swallowing disorder resulting from issues with the oral cavity, pharynx, esophagus, or gastroesophageal junction (ASHA, 2018). The swallowing process has been divided into three phases, oral, pharyngeal, and esophageal (Bülow, Speyer, Baijens, Woisard, & Ekberg, 2008; Konecny & Elfmark, 2008). Effective and safe swallowing requires precise coordination and timing of both nervous and muscular functions (Bülow et al., 2008). However, there are many different neurogenic, neoplastic, and vascular events or accidents that can impact the effectiveness of swallowing function and result in dysphagia. Dysphagia can have significant impacts on an individual's life and statistics suggest that nearly 15 million adults in the United States present with dysphagia (Blumenfeld, Hahn, LePage, Leonard & Belafsky, 2006). Common medical complications associated with dysphagia include malnutrition, dehydration, aspiration pneumonia, and even death (Blumenfeld et al., 2006). The authors of this systematic review focused on adults with dysphagia resulting from various etiologies. Current dysphagia intervention for adults, which is referred to as traditional dysphagia treatment (TDT) throughout this review, consists of diet modification, compensatory strategies involving postural adjustments, and swallowing exercises to strengthen musculature (Blumenfeld et al., 2006).

Electrical stimulation (ES) is a relatively new dysphagia treatment approach but has been used in physical therapy to prevent atrophy, stimulate striated muscle, and aid in wound healing (Blumenfeld et al., 2006). A common type of electrical stimulation is known as neuromuscular electrical stimulation (NMES). In NMES, a clinician delivers electrical pulses through surface electrodes externally placed on the patient's skin to innervate the targeted muscle (Li, Huang, Yin, Shen, & Shi, 2015). This, in turn, creates an action potential that results in a muscular

contraction. There is much evidence to support the use of ES in the physical therapy literature, concluding that ES can "optimize recovery of muscle strength" as it evokes the activity of motor units that are difficult to activate during voluntary contraction (Hainaut & Duchateau, 1992). Given its success in physical therapy, many speech-language pathologists have begun implementing the use of ES to treat individuals with dysphagia. It is hypothesized, if an individual suffers from dysphagia secondary to an event that caused weakness to the swallow musculature, ES would be an effective modality to support the strengthening of the muscle.

In the field of speech-language pathology, the literature regarding NMES is controversial and there is conflicting evidence to suggest its effectiveness as a dysphagia intervention when used alone (Sproson, Pownall, Enderby, & Freeman, 2018). However, there is a growing body of evidence to suggest effectiveness of NMES when used in conjunction with TDT (e.g., compensatory strategies; Sproson et al., 2018). Researchers suggest NMES can aid in natural recovery processes related to swallowing (Vasant et al., 2016). The studies included in this review discuss ES, NMES, transcutaneous NMES, pharyngeal electrical stimulation (PES), and VitalStim. The authors of the review chose to include all types of ES.

Purpose

The purpose of this systematic review is to evaluate the efficacy of ES as a dysphagia intervention when used alone, or in conjunction with TDT. This review will evaluate the efficacy of ES when used with adults with varying types and severities of dysphagia, resulting from any medical condition or event.

Methodology

To identify studies relevant to this systematic review, database searches were conducted from September 2018 through February 2019. The electronic databases used were Ovid

MEDLINE, PubMed, PsycINFO, and Google Scholar. Six of the studies were hand-selected through other sources and reference lists of relevant systematic reviews to expand the results. The search terms used in the databases consisted of a variety of subject headings and keywords to narrow down the search measures. The main subject headings and search terms used were dysphagia; deglutition disorders; swallowing disorders; oral/pharyngeal dysfunction; oropharyngeal dysfunction; oropharyngeal dysphagia; pharyngeal dysphagia; electrical stimulation; e-stim; VitalStim; neuromuscular electrical stimulation. All research designs were considered that were published within the last twenty-five years (1994-2019). The searches were specific to interventions and disorders related to our systematic review.

Each reviewer examined the studies identified through the database searches to determine whether inclusionary and exclusionary criteria were met. For the study to be included in the systematic review, the following criteria must have been met: 1) individuals age 18 and older; 2) diagnosis of any type of dysphagia (oral, pharyngeal, esophageal, etc.); 3) dysphagia as a result of any disorder or disease; and 4) ES independent of other dysphagia treatment OR ES used in conjunction with TDT. Studies were excluded from the systematic review if they met any of the following criteria: 1) individuals with tracheostomies; 2) individuals with enteral feeding; and 3) individuals who are NPO (nothing by mouth). Once the criteria measures were qualified for each study, the abstract was then reviewed to determine if each met the outlined inclusionary criteria.

Data Extraction/Quality Assessment

The quality assessment of each study was completed by three appraisers. The appraisers rated the quality of the studies independently then as a group based on nine criteria. The nine criteria rated were intervention and comparator of interest defined; randomization considered; potential of confounding factors; blinding assessed; clinical outcomes considered;

generalizability of data; reliability/validity; baseline characteristics and matching groups; inclusion/exclusion specified. A quality assessment score 'high' was given if the study met seven or more of the criteria, a 'moderate' score was given if it met four to six of the criteria, and a 'low' score was given if the study met three or fewer of the criteria.

Outcome Measures

The primary instrument used to assess swallow function in the individuals studied was a videofluoroscopic swallowing study (VFSS). Specific areas of measures related to VFSS outcomes looked at pharyngeal transit time (PTT), oral transit time (OTT), pharyngeal delay time (PDT), and laryngeal closure duration (LCD). The primary outcome measures used were the functional oral intake scale (FOIS), penetration-aspiration scale (PAS), visual analog scale (VAS), and swallowing quality of life questionnaire (SWAL- QoL). Other outcome measures that were used were the eating assessment tool (EAT-10), M. D. Anderson Dysphagia Inventory (MDADI), functional dysphagia scale (FDS), clinical dysphagia scale (CDS), and other less frequently used measurement tools.

Results

Among the 527 initial studies identified by the search strategy, 57 were selected for a full review of the text. Of these, 21 studies met the inclusion criteria and were included in this systematic review. A number of studies were excluded due to participant-characteristics outside of the inclusionary criteria, inability to access the text in English, and duplicates of same studies. Figure 1 depicts the full details of the search strategy.

The 21 studies included within this systematic review were published between 1997 and 2018 and were conducted in the USA, Europe, and Asia. These studies included a total of 1,074 participants and study designs varied from randomized control studies, prospective studies,

single-case studies, pilot studies, to cohort studies. Ten of the studies focused on participants who presented with dysphagia secondary to a cerebrovascular accident (CVA). The remaining 11 included participants with Parkinson's Disease (PD), multiple sclerosis (MS), traumatic brain injury (TBI), head and neck cancer, and respiratory failure.

The overall quality of the included studies was moderate. Fifteen of the 21 studies included an experimental group and a control group. In these 15 studies, all participants were matched for age, gender, and diagnosis, suggesting no significant differences between the two groups. Nineteen of the included studies reported on their inclusion criteria while 15 of the studies reported on their exclusion criteria. Five of the studies reported adequate reliability (i.e., interrater reliability) of at least one outcome measure and three studies reported adequate validity, resulting in 13 studies that did not adequately or did not at all report on the reliability and/or validity of their outcome measures. Nineteen of the 21 studies presented with selection bias as the studies targeted specific populations (i.e., post-stroke, multiple sclerosis, Parkinson's Disease). As a result, the findings of these studies are limited in their generalizability to only the specific populations included. Table 1 presents the full details regarding the characteristics of the included studies, along with their level of quality.

For the 10 studies in which participants presented with dysphagia secondary to a CVA, 8 of the studies revealed statistically significant improvements in the participants' swallow functionality (Bülow et al., 2008; Konecny & Elfmark, 2018; Lee et al., 2014; Li et al., 2015; Park, O'Neill, & Martin, 1997; Permsirivanich et al., 2009; Sproson et al., 2018; Zhang et al., 2016). The remaining 11 studies included in the systematic review assessed the efficacy of ES in dysphagic participants secondary to a variety of etiologies. Two studies assessed participants with dysphagia secondary to PD and neither study found statistically significant results.

However, the results demonstrated positive outcomes that were trending toward statistical significance. Two studies assessed participants with dysphagia secondary to MS. Both studies found statistically significant improvements in all outcome measures (Bogaardt et al., 2009; Restivo et al., 2013).

One study, conducted by Beom, Kim, & Han (2011), included participants with TBI and found no significant changes in outcomes. Two studies assessed participants with dysphagia secondary to head and neck cancer. For one study, the researchers Lin and colleagues (2011) found significant improvements on all outcome measures in the NMES group when compared to the control group. Ryu and colleagues (2008), however, found no statistically significant improvements. The remaining five studies included participants with various etiologies who all presented with chronic, moderate-to-severe dysphagia. Of the five, three studies concluded statistically significant results for their experimental cohort while one reported positive improvement trending toward clinical significance. These studies were conducted by Blumenfeld et al., (2006); Carnaby-Mann & Crary (2008); Frost, Robinson, & Hibberd (2018); and Leelamanit, Limsakul, & Geater (2002). The remaining study, conducted by Lee, Park, Lee, & Choi (2017), found improvements in the strength of the swallow musculature; however, the improvements were not great enough to be considered statistically significant.

Among the 21 included studies, ten studies used VitalStim, a common electrical stimulation program used in the treatment of dysphagia. In these ten studies, VitalStim was provided by certified professionals who had undergone the VitalStim certification program. Eight of the studies did not use VitalStim, and the remaining three used the VitalStim machine but did not specify if the treatment adhered to the VitalStim program or if it was provided by a certified VitalStim professional.

Discussion

Dysphagia secondary to CVA

Research suggests that dysphagia is common following a CVA, affecting 45% to 65% of individuals who suffer from acute strokes (Lee et al., 2014). Of the 10 studies in this review that were specific to CVA, four of them were conducted in the United Kingdom, two were conducted in China, two in Korea, one in the Czech Republic, and one in France, the Netherlands, and Sweden. Sample size in these studies ranged from four patients to 135 patients.

Five of the CVA-specific studies included experimental groups with ES used in conjunction with TDT. Three of these five studies demonstrated statistically significant results when using ES in combination with TDT versus TDT used in isolation. These three studies all focused electrode placement on suprahyoid musculature. Li and colleagues (2015) randomly assigned 135 patients to three groups; TDT in isolation, VitalStim, and VitalStim used in conjunction with TDT. The researchers conducted the study across four weeks using VFSS to assess swallow function and comparing pre and post treatment results using the VAS and the Standardized Swallowing Assessment (SSA; Li et al., 2015). The researchers concluded that VitalStim in conjunction with TDT can improve swallow function in post-stroke patients (Li et al., 2015). Sproson and colleagues (2018) included 30 patients and randomly assigned participants to a usual care group and an Ampcare Effective Swallowing Protocol (ESP) group. 'Usual care' was defined as postural adaptations, exercise programs, and modified oral intake (Sproson et al., 2018). This aligns with the reviewers previously outlined definition of TDT. The Ampcare ESP group involved strengthening exercises used in conjunction with NMES (Sproson et al., 2018). Sproson and colleagues (2018) conducted the study across four weeks and used the FOIS, PAS, and SWAL-QOL to determine outcomes. Based on the statistically significant

results in the Ampcare ESP group, the researchers concluded NMES combined with exercises demonstrated clinically significant improvements as well as better patient satisfaction outcomes (Sproson et al., 2018). Lee and colleagues (2014) conducted a study with 57 patients assigned to TDT with NMES or TDT only groups. The study was performed across three weeks, with NMES being delivered five days a week (Lee et al., 2014). Researchers found statistically significant differences between the groups at three- and six-weeks follow-up (Lee et al., 2014). Researchers concluded NMES can be used as a supplementary treatment to TDT to improve swallow function (Lee et al., 2014). The two studies using ES combined with TDT that did not demonstrate statistically significant results found clinically significant improvements in swallow function, however the differences were not large enough to be considered statistically significant.

Bath and colleagues (2016) and Vasant and colleagues (2016) conducted two separate studies with ES groups compared to sham groups. Neither study revealed statistically significant results between the groups; however, the authors presented that there were no negative outcomes associated with the use of ES. Bath and colleagues (2016) hypothesized that small sample size and undertreatment of patients (only 2 weeks of treatment) receiving ES may have contributed to study results. Vasant and colleagues (2016) presented clinically meaningful swallowing improvement in ES group, however the researchers identified study size and limited recruitment as study limitations.

Beom and colleagues (2011) included 28 patients and randomly assigned participants to conventional dysphagia management (CDM) and ES of suprahyoid muscles (ESSM) groups. Results of this study indicated no statistical significance, however similar to other studies, more patients in the ESSM group showed improvement in comparison to the CDM group. Park and colleagues (1997) conducted a single-case study design with four participants and two of the

participants demonstrated improved swallow function. However, these improvements were not statistically significant (Park et al., 1997). This study is different than the majority included in this review because electrical stimulation was administered to the soft palate instead of throat regions.

Based on these studies there is evidence to support the use of ES in conjunction with TDT for patients who have suffered CVAs. However, as demonstrated by these studies the efficacy of ES seems to be related to the frequency, intensity, and duration of treatment. Specific electrode placement during ES intervention also may be related to swallowing outcomes. Sproson et al. (2018) was the only study to identify specific components of TDT that were used in conjunction with ES (strengthening exercises). Identifying the most effective components of TDT to combine with ES intervention is an area in need of further research.

Dysphagia secondary to PD

Oropharyngeal dysphagia is common amongst individuals with PD. Heijnen, Speyer, Baijens, and Bogaardt (2012) stated 80% of individuals with PD will experience oropharyngeal dysphagia in the first stage of the disease. Typical dysphagia treatment for individuals with PD consists of oral-motor exercises, postural changes, and air-way protecting maneuvers (Heijnen et al., 2012). Though both studies reported no significant differences, they did reveal small improvements in the swallowing abilities of the individuals with PD. This could be related to assessing individuals with moderate PD compared to individuals with severe PD. Heijnen and colleagues (2012) hypothesized more significant differences between the experimental and control groups could have been noted if the study involved individuals who presented with more severe impairments at the beginning of treatment. Baijens and colleagues (2012) also addressed this issue, stating individuals at the early stages of PD have more ‘intact’ swallowing abilities

compared to individuals further along in progression of the disease. As such, individuals with more intact swallowing abilities would demonstrate smaller improvements in treatment outcomes, which would possibly correlate with less statistically significant results. Another possible explanation for the lack of significant results is, unlike other disorders or etiologies, dysphagia secondary to PD may be due to neurological damage to the control of swallowing rather than muscle weakness (Heijnen et al., 2012). Further studies related to PD and ES should include a larger range of severity of PD, a longer time period of study, and differing stimulation variables.

Dysphagia Secondary to MS

Traditional therapy approaches for treating swallowing difficulties for individuals with MS are limited to diet modification and compensatory strategies. Oral-motor exercises are not recommended for this population due to an increase in symptom exacerbation, resulting in furthering fatigue *(*Boggardt et al., 2009). Two studies included in this systematic review were specific to patients with dysphagia resulting from MS. Boggardt and colleagues (2009) found statistically significant improvements in the participants who received NMES, noting decreased pooling of saliva and reduced aspiration. The other study specific to MS was completed by Restivo and colleagues (2012) demonstrated statistically significant improvements across all reported outcome measures. Both of these studies suggest evidence to support the use of ES for individuals with MS. Further research in this area is needed to provide more evidence regarding the effectiveness of PES in treating all individuals with MS who also present with dysphagia. In Restivo and colleagues (2012), the majority of participants had the same lesion site, specific to the medulla oblongata. It is unknown, from this study, if PES would also be effective for individuals with MS who present with lesions in other areas of the brain (Restivo et al., 2012).

Dysphagia Secondary to Cancer

Dysphagia associated with head and neck cancer is due to tumor growth, or damage/scarring from surgery, radiation, or chemotherapy (Ryu et al., 2008). The effectiveness of ES therapy is unknown and limited in the research available on head and neck cancer. Two studies included in our systematic review were specific to individuals with dysphagia secondary to head and neck cancer. One of the two studies showed a statistically significant measure for improvements in swallowing when treating with ES. Both studies showed better outcomes in the group receiving ES. Though changes in swallowing function were observed across both studies, there are many limitations in dysphagia treatment for individuals with head and neck cancer. This is related to the extensive damage that can occur to the muscles, oral structures, or extent and size of the tumors. Therefore, the success of ES in treating dysphagia cannot be generalized to all individuals with head and neck cancer.

Dysphagia Secondary to Other Etiologies

Five of the 21 included studies did not focus on a specific population but instead assessed individuals with chronic, moderate-to-severe dysphagia. Etiologies resulting in dysphagia included in these studies ranged from respiratory failure, sepsis, unspecified neurological origin, syringomyelia, cervical-spine surgery, to old age. Although three studies yielded statistically significant results and two studies demonstrated positive outcomes, the generalizability of the results are limited due to the studies' inclusion of multiple etiologies and small sample sizes. However, the positive improvements made in each of the five studies suggest ES may be a beneficial intervention to implement but the method of implementation, such as electrode placement and intensity of electrical pulses, should be tailored to meet the needs of the specific population. An individual who presents with dysphagia as a result of old age may not need as

high intensity of electrical pulses as someone who has dysphagia as result of a neurological origin.

Study Limitations & Clinical Implications

This systematic review included a comprehensive search of databases for relevant studies. The authors also completed a quality assessment with three independent reviewers for each study. However, limitations are present and must be acknowledged. Overall limitations of the studies included in this systematic review include small sample size, heterogeneity of the samples, and varying quality of study designs. For example, three studies were rated as low or low/moderate quality. Further research is needed to determine efficacy of electrical stimulation as an independent intervention approach for dysphagia. Further research is also needed to determine the most effective placement of electrical stimulation, as well as most effective frequency, intensity, and duration of treatment. Additional studies are needed in order to explore generalizability of electrical stimulation efficacy in individuals with dysphagia resulting from various etiologies.

Conclusions

The results of this systematic review revealed inconsistent reports of statistical significance regarding the efficacy of ES intervention for adults with dysphagia. Even within studies that assessed participants who presented with dysphagia secondary to similar etiologies, this inconsistency was evident. As a result, a definitive recommendation for the implementation of ES in treating adults with dysphagia cannot be made. However, a majority of the studies included in this systematic review did demonstrate an overall trend in improving swallow functionality in the participants who received ES in conjunction with TDT, and no studies reported negative outcomes associated with the use of ES. While this trend suggests promise for

the use of ES in treating adults with dysphagia, further research is needed to conclusively determine the efficacy of ES as an independent intervention approach.

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Figure 1: Search strategy flow chart

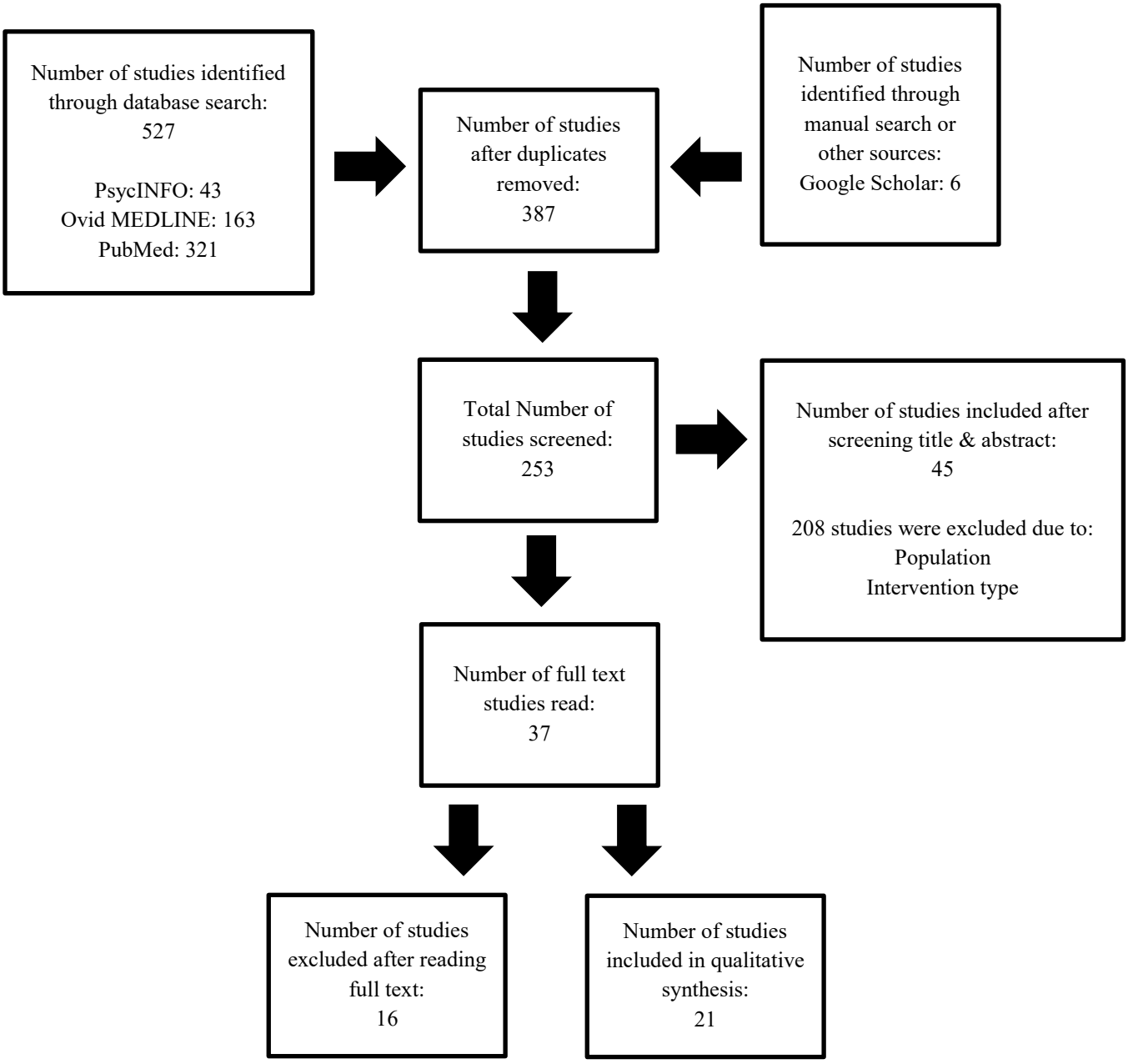

Table 1: Study characteristics and quality assessment

First author (year), country	Type of Study	Participants			Baseline Comparability			Outcome measures			Data	Biases	Level of Quality
	Fill in	Diagnosis	Age and gender	Experimental group	Control group (as appropriate)	Presented	Inclusion criteria specified	Exclusion criteria specified	Instruments used	Reliability presented	Validity presented	Significant changes	Fill in	
Baijens (2012), Netherlands	Case control	Parkinson's Disease	Mean: 66 M: 14 F: 6	10	10	✓	✓	✓	VFSS	✓	✓	No	Selection bias	High
Bath (2016), United Kingdom	Control study	Subacute CVA	Mean: 74 M: 94 F: 68	87	75	✓	✓	✓	PAS, DSRS, VFSS	NS	NS	No	Selection bias Confounding bias	Moderate
Beom (2011), Korea	Control comparative study	CVA or TBI	Ex Mean: 66 M: 3 F: 4 Co Mean: 68 M: 9 F: 12	7	21	✓	✓	✓	VDS, ASHA NOMS, VFSS	NS	NS	No	Selection bias Rater bias	Moderate
Blumenfeld (2006), USA	Cohort study	Respiratory failure, CVA, sepsis, other chronic conditions	Mean: 72 M/F: No data	40	40	✓	NS	NS	Swallow Function Scoring system (0-6 scale)	NS	NS	Yes, for all outcome measures	Selection bias Rater bias	Moderate
Bogaardt (2009), Netherlands	Interventional study	Multiple sclerosis	Mean: 53.1 M: 9 F: 16	25	N/A	✓	✓	NS	DSS, PAS, FEES	NS	NS	Yes, for all outcome measures	Selection bias	Moderate
Bülow (2008), Netherlands, Sweden, France	Experimental study	Hemispheric CVA	Mean: 70 M: 16 F: 9	12	13	✓	✓	✓	VAS, VFSS, ANS, OMFT	NS	NS	No	Attrition bias Selection bias	Moderate

Notes: ✓ Yes (adequately addressed); x No (not adequately addressed); ✓x partially (partially addressed); NS – not stated; N/A – not applicable; CVA = cerebrovascular accident; TBI = traumatic brain injury; VFSS = videofluoroscopic swallowing study; PAS = penetration aspiration scale; DSRS = dysphagia severity rating scale; VDS = videofluoroscopic dysphagia scale; ASHA NOMS = American Speech-Language-Hearing Association National Outcome Measurement System; DSS = dysphagia severity scale; FEES = flexible endoscopic evaluation of swallowing; VAS = visual analog scale; ANS = actual nutrition status; OMFT = oral motor function test

First author (year), country	Type of Study	Participants			Baseline Comparability				Outcome measures				Data	Biases	Level of Quality
	Fill in	Diagnosis	Age and gender	Experimental group	Control group (as appropriate)	Presented	Inclusion criteria specified	Exclusion criteria specified	Instruments used	Reliability presented	Validity presented	Significant changes	Fill in		
Carnaby-Mann (2008), USA	Prospective case series	Chronic pharyngeal dysphagia	Range: 33-85 M: 4 F: 2	6	N/A	✓	✓	✓	MASA, FOIS, VFSS, Detecto Scale	✓	x	Yes, for all outcome measures	Selection bias	Moderate
Frost (2018), United Kingdom	Case study	Dysphagia	Mean: 80 M: 9 F: 1	10	N/A	✓	✓	✓	FOIS, EAT-10, SWAL-QoL	NS	NS	Yes, for FOIS	Selection bias Rater bias	Moderate
Heijnen (2012), Netherlands	Control study	Parkinson's Disease	Mean: 68 M: 65 F: 23	NMES Motor: 27 Sensory: 30	28	✓	✓	✓	DSS, SWAL-QoL, MDADI	✓	✓	Yes	Selection bias Confounding bias	High
Konecny (2018), Czech Republic	Prospective randomized study	Early stage CVA	Ex Mean: 70 Co Mean: 69 M: 57 F: 51	54	54	✓	✓	NS	VFSS – oral transit time (OTT) and pharyngeal transit time (PTT)	NS	NS	Yes, for all outcome measures	Rater bias Selection bias	Moderate
Lee (2017), Korea	Case study	Oropharyngeal dysphagia	Mean: 72 M: 1	1	N/A	✓	NS	NS	IOPI, VFSS, VDS, PAS	NS	NS	No	Rater bias Selection bias	Low
Lee (2014), Korea	Control study	Subacute/ acute ischemic CVA	Ex Mean: 63.5 Co Mean: 66.7 M: 42 F: 15	31	26	✓	✓	✓	VFSS, FOIS	NS	NS	Yes, for all outcome measures	Rater bias Confounding bias Selection bias	High

Notes: ✓ Yes (adequately addressed); x No (not adequately addressed); ✓x partially (partially addressed); NS – not stated; N/A – not applicable; CVA = cerebrovascular accident; MASA = Mann assessment of swallowing ability; FOIS = function oral intake scale; VFSS = videofluoroscopic swallowing study; EAT-10 = Eating assessment tool 10; SWAL-QoL = swallowing quality of life; DSS = dysphagia severity scale; MDADI = MD Anderson dysphagia inventory; IOPI =Iowa oral performance instrument ; VDS = videofluoroscopic dysphagia scale; PAS = penetration aspiration scale

First author (year), country	Type of Study	Participants				Baseline Comparability			Outcome measures			Data	Biases	Level of Quality
	Fill in	Diagnosis	Age and gender	Experimental group	Control group (as appropriate)	Presented	Inclusion criteria specified	Exclusion criteria specified	Instruments used	Reliability presented	Validity presented	Significant changes	Fill in	
Leelamanit (2002), Thailand	Prospective study	Dysphagia	Range: 35-87 M: 11 F: 12	23	N/A	✓	✓	✓	VFSS	NS	NS	No	Attrition bias	Low/ Moderate
Li (2015), China	Control study	CVA	Mean: 66.2 M: 69 F: 66	VS: 45 VS + TDT: 45	45	✓	✓	✓	VAS, SSA, VFSS	NS	NS	Yes, for VS + TDT group	Attrition bias Selection bias	High
Lin (2009), Taiwan	Randomized control study	Nasopharyngeal carcinoma	Mean: 54.2 M: 6 F: 4	5	5	✓	✓	✓	VFSS, PAS, DOSS, MDADI	✓	NS	Yes, for all outcome measures	Selection bias Rater bias	Moderate
Park (1997), United Kingdom	Single case study	CVA		4	N/A	✓	✓	x	VFSS	NS	NS	Yes, in 2/4 patients	Observation bias	Low/ Moderate
Permsirivanich (2009), Thailand	Control study	CVA	Ex Mean: 64.5 Co Mean: 64.7 M: 9 F: 14	12	11	x	✓	NS	FOIS, number of treatment sessions	✓x	✓x	Yes, for FOIS	Attrition bias Selection bias	Moderate
Restivo (2013), Italy	Pilot study	Multiple sclerosis	Mean: 39.7 M: 7 F: 13	10	10	✓	✓	✓	VFSS, PAS	NS	NS	Yes, for all outcome measures	Rater bias Selection bias	Moderate
Ryu (2008), Korea	Case control study	Head and neck cancer	Mean: 63 M: 25 F: 1	14	12	✓	✓	✓	CDS, FDS, ASHA NOMS, MDADI	✓	✓	No	Selection bias Detection bias	High

Notes: ✓ Yes (adequately addressed); x No (not adequately addressed); ✓x partially (partially addressed); NS – not stated; N/A – not applicable; CVA = cerebrovascular accident; VS = VitalStim; TDT = traditional dysphagia treatment; VFSS = videofluoroscopic swallowing study; VAS = visual analog scale; SSA = standardized swallowing assessment; PAS = penetration aspiration scale; DOSS = dysphagia outcome and severity scale; MDADI = MD Anderson dysphagia inventory; FOIS = functional oral intake scale; CDS = clinical dysphagia scale; functional dysphagia scale; ASHA NOMS = American Speech-Language-Hearing Association National Outcome Measurement System

First author (year), country	Type of Study	Participants				Baseline Comparability			Outcome measures			Data	Biases	Level of Quality
	Fill in	Diagnosis	Age and gender	Experimental group	Control group (as appropriate)	Presented	Inclusion criteria specified	Exclusion criteria specified	Instruments used	Reliability presented	Validity presented	Significant changes	Fill in	
Sproson (2018), United Kingdom	Control study	CVA	Ex Mean: 73 Co Mean: 81 M: 19 F: 11	15	15	✓	✓	✓	FOIS, PAS, SWAL-QoL	✓x	✓x	Yes	Rater bias Selection bias Attrition bias	Moderate
Zhang (2016), China	Prospective controlled study	Medullary CVA	Mean: 62 M: 17 F: 10	SA + TDT: 28 MA + TDT: 27	27	✓	✓	✓	Water swallow test, SSA, FOIS, SWAL-QoL, MMSE	NS	NS	No	Rater bias Selection bias	Moderate

Notes: ✓ Yes (adequately addressed); x No (not adequately addressed); ✓x partially (partially addressed); NS – not stated; N/A – not applicable; CVA = cerebrovascular accident; SA = sensory approach; MA = motor approach; TDT = traditional dysphagia treatment; FOIS = functional oral intake scale; PAS = penetration aspiration scale; SWAL-QoL = swallowing quality of life; SSA = standardized swallowing assessment; MMSE = mini-mental state examination