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Dose in Exercise-Based Dysphagia Therapies: A Scoping Review

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Abstract

Background—Optimal exercise doses for exercise-based approaches to dysphagia treatment are unclear. To address this gap in knowledge, we performed a scoping review to provide a record of doses reported in the literature. A larger goal of this work was to promote detailed consideration of dosing parameters in dysphagia exercise treatments in intervention planning and outcome reporting.

Methods—We searched PubMed, Scopus[Embase], CINAHL, and Cochrane databases from inception to July 2019, with search terms relating to dysphagia and exercises to treat swallowing impairments. Of the eligible 1906 peer-reviewed articles, 72 met inclusionary criteria by reporting, at minimum, both the frequency and duration of their exercise-based treatments.

Results—Study interventions included tongue exercise (n=16), Shaker/head lift (n=13), respiratory muscle strength training (n=6), combination exercise programs (n=20), mandibular movement exercises (n=7), lip muscle training (n=5), and other programs that did not fit into the categories described above (n=5). Frequency recommendations varied greatly by exercise type. Duration recommendations ranged from 4 weeks to 1 year. In articles reporting repetitions (n=66), the range was 1 to 120 reps/day. In articles reporting intensity (n=59), descriptions included values for force, movement duration, or descriptive verbal cues, such as "as hard as possible." Outcome measures were highly varied across and within specific exercise types.

Conclusions—We recommend inclusion of at least the frequency, duration, repetition, and intensity components of exercise dose to improve reproducibility, interpretation, and comparison across studies. Further research is required to determine optimal dose ranges for the wide variety of exercise-based dysphagia interventions.

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Keywords

scoping review; dysphagia treatment; dose; evidence-based practice

Introduction

Exercise-based approaches have been used in dysphagia treatment for over three decades. The overall aim of these treatments is to increase the strength and endurance of muscle groups involved in deglutition and airway protection. These exercise approaches target specific muscles or groups of muscles active in deglutition including the oral musculature (maximum isometric pressure of tongue, lips, jaw), pharyngeal constrictors (effortful swallow, Masako), hyolaryngeal complex (Mendelsohn, Shaker Head Lift), and respiratory muscle complex (inspiratory and expiratory muscle strength training) [1]. It is intuitive that exercise dose is an essential component of any exercise-based therapy, and understanding the relationship between dose and treatment efficacy is critical to maximizing patient benefit. As such, importance of dose in resistance exercise has been well established in the limb literature [2–6]. However, definitive guidelines for optimal dosing in swallowing rehabilitation programs have yet to be established [7, 8]. Because of critical differences that exist between skeletal muscles of the head and neck and the limb in terms of muscle structure, biology, and physiology [8], it is important to develop exercise dose recommendations specific to deglutatory musculature and not rely on prescriptions developed for limb muscles. Recognizing this gap in knowledge, we reviewed the literature to explore the range of exercise doses reported in research on exercise-based interventions to treat dysphagia.

Scoping Review

To gain perspective on reporting of exercise dose information in the dysphagia literature, we performed a scoping review, which is defined as: “[a] preliminary assessment of the potential size and scope of available research literature. It aims to identify the nature and extent of research evidence” (p. 101) [9]. A scoping review does not require the in-depth critique of research quality typically performed in a systematic review [10] and is useful for examining a particularly heterogeneous literature base. In contrast to a systematic review, a scoping review can provide a more inclusive reference guide of research evidence available regarding exercise dosing. The purpose of this scoping review was twofold: 1) To provide researchers and clinicians with a record of currently reported exercise dosing in the adult and geriatric dysphagia therapy literature base; 2) To call attention to important components of exercise dosing that should be considered in every exercise-based study and should be reported in dysphagia treatment methodology both in clinical practice and peer reviewed manuscripts.

Relationship between Exercise Dose and Muscular Conditioning

Both endurance exercise and resistance exercise have been studied in skeletal muscle and cardiorespiratory systems [11]. Endurance exercise (aerobic) can last from minutes to hours, and makes use of high-repetition actions at low resistance to maximize changes in skeletal muscle oxidative capacity [12]. Resistance exercise (anaerobic) involves high resistance training with the goal of increasing muscular mass and power [12]. Endurance exercise increases signaling for mitochondrial biogenesis in muscles of the limbs with chronic exercise effects resulting in increased mitochondrial content and function leading to improved muscular capacity and fatigue resistance [13–17] The primary goal of resistance exercise is to increase muscle strength by increasing muscle fiber cross-sectional area (CSA), also known as muscular hypertrophy. These increases in size occur both in young and elderly individuals with resistance exercise training [2, 18].

Depending on the goals of an exercise-based treatment program, there can be a focus on resistance training, endurance training, or can involve a combination of both (concurrent training). Dysphagia exercise programs have generally focused on increasing strength, using fewer repetitions at increasing resistance, however some exercises do involve a component of endurance (e.g. hea sustained head-lift exercise) [19]. Since a majority of dysphagia exercise programs include some component of strength training, we will focus this introductory discussion on effects of strength training on muscle biology.

Muscular hypertrophy is achieved when a muscle or group of muscles contracts to resist against increasingly higher loads, above what is normally required of that particular muscular system [20–22]. Increasing load challenges the muscle(s), requiring higher-threshold motor units to be activated [20–22] and promotes protein signaling to induce muscular hypertrophy [23–25]. Gains in muscular strength observed after resistance exercise are due, in part, to muscular protein synthesis increasing fiber size (hypertrophy) and number as well as other shifts in muscle fiber composition and metabolism towards a more powerful, fatigue resistant profile [26–29]. At the cellular level, among other related processes, resistance exercise can increase fiber number by inducing quiescent satellite cells to enter the mitotic cycle and differentiate to promote new myofiber development [30, 31].

Mechanisms involved in muscular hypertrophy and conditioning with exercise are known to increase in a dose-dependent manner [6], making consideration of dose in exercise particularly important. The relationship between resistance exercise dose and muscular hypertrophy have been explored and debated in the limb literature with the goal of optimizing dose prescription to maximize strength-related outcomes [5, 6]. Relationships between training intensity and frequency have been well studied, and these findings have contributed to the American College of Sports Medicine (ACSM) Guidelines for Exercise Testing and Prescription (9^{th} Edition) [32]. With increasing intensity of resistance exercise there is a corresponding increase in the synthesis of myofibrillar proteins [33]. Similarly, increasing resistance exercise training frequency (number of training sets/week) is related to increasing muscular hypertrophy in a graded, dose-responsive manner [34].

Other important considerations in determining dose prescription are training status and the risk of over-prescription. Meta-analyses in the exercise science literature have supported differences in optimal dose considerations for trained vs untrained individuals (outlined below), which will impact how exercise is prescribed [5]. More importantly, incorrect dose prescription could result in over-prescription of exercise, which can have negative or “diminishing” effects [5, 6]. These are critical factors to consider when designing a training program: improper and over-training can lead to reductions in strength and can increase risk of injury [6]. As such, exercise scientists who study effects of dose-response in the limb have made the following recommendations regarding training doses for individuals wishing to prevent age-related changes in muscle and induce muscle hypertrophy [5, 6, 32]:

- For untrained individuals: 60% of 1 Rep-Maximum (RM); 4 sets (1 set = 8–12 repetitions); 3 days/week
- For trained individuals: 80% 1RM; 4 sets; 2 days/week
- For trained athletes: 85% 1RM; 8 sets; 2 days/week

These doses have been well studied and explored in muscles of the limbs and trunk, dose-response recommendations for muscles of the head and neck have not been definitively determined [1, 7]. While the work of the limb and exercise science literature can provide a starting point for developing dosing for exercise-based dysphagia therapies, structural and physiological differences between the limb vs cranial musculature [8] require us to explore effects of exercise dose in our muscles of interest, specifically.

Components of Exercise Dose in Dysphagia Therapy

When considering dose-related effects in exercise therapy, there are several components of dose that must be considered. Depending on the type of exercise, and the muscle systems targeted (limb, trunk, cranial), different terminology might be used to describe similar components. The ACSM's Guidelines for Exercise Testing and Prescription (9^{th} Edition) lists 9 components of exercise: frequency, intensity, time (duration), type, repetitions, sets, pattern (rest intervals), and progression. We combined items on this list into four components of exercise dose that are relevant and necessary in a dysphagia treatment prescription (represented in Figure 1 and described below): Frequency (frequency, sets), Repetitions, Intensity, Duration [32].

Repetitions are defined as the number of actions performed in one set of a specific exercise maneuver. For example, 10 lingual presses or 40 effortful swallows constitutes the number of repetitions of an action.

Frequency defines how many of "sets" of exercise are performed in one day or session, and how many days of exercise per week are prescribed. One "set" of exercise is defined by the number of repetitions in the set. For example, exercise prescription could include performance of 3 sets of 10 lingual presses per day for 3 days per week. This translates into the patient performing 30 lingual presses per day (in each of 3 sessions) and thus 90 presses total per week. The amount of rest between individual repetitions has not been well defined, nor has the optimal number of total sets recommended for performance in one day. In the exercise science literature, sets per day are used to break up the number of repetitions of an action performed to allow for periods of rest. The ACSM recommends between 2–3 minutes for rest between sets [32]. However, other than the Shaker exercise, there are no current guidelines regarding proper rest between sets of other exercises to treat dysphagia [1]. Given the limited research and reporting on this topic, we did not include rest as a dosing component in this review. However, it should be considered in future studies of dysphagia exercise.

Intensity reflects the amount of effort or force exerted during a single repetition of an exercise. This can be measured by percentage of a maximum amount of effort, if using a device-facilitated approach, or a more descriptive criterion, such as "press has hard as you can" or "using maximum amount of effort." For an isometric exercise, length of hold can serve as a definition of intensity. While having a device-facilitated program will most accurately capture intensity, providing participants with a qualitative description of level of intensity is an acceptable way of ensuring successful execution of a specific strengthening maneuver.

Duration of the exercise program is the total length of the exercise program, and can be defined by a number of sessions, weeks, months, or other similar metric. The duration also represents the final endpoint at which patients can be expected to see measurable, clinical improvement in function. The exercise science literature recommends between 8–12 weeks for progressive resistance training programs [2]. However, the optimal duration for exercise treatments for dysphagia have not been determined. Without defining a specific program duration, clinicians and researchers are unable to compare program outcomes or define an end point for expected clinical improvement.

We considered these components as basic dosing parameters during our scoping review for ensuring reproducibility of exercise conditions. In this review, we aimed to highlight study parameters of frequency, repetition, intensity, and duration of clinically relevant exercises to allow comparison across articles. While interpreting the specific effects of swallowing exercises was beyond the scale of the current study, we reported the primary outcomes and statistical findings to summarize the existing evidence of treatment effects on swallow-related outcomes for each individual study.

Methods for Scoping Review

This scoping review was performed with the assistance of two librarians (SJ, MC). We searched 4 databases (PubMed, Scopus[Embase], CINAHL, Cochrane, Figure 2.) with search terms customized for each database, and included variations of Dysphagia, Deglutition disorders, Swallowing disorder, Shaker exercise, Mendelsohn maneuver, Masako exercise, Tongue hold, Effortful swallow, Protective airway maneuver, Tongue pressure resistance, and Iowa Oral Performance Instrument, among others (please see Appendix for full listing of MeSH terms). The literature search in this study was limited to peer-reviewed publications in the broad area of exercise treatment of adults with dysphagia that were published on or prior 7/2019. No other study design criteria were employed for the literature search, in accordance with generally accepted scoping review methodology [9].

All 1906 citations were reviewed by both the first and second author (BNK, LMR). Criteria for inclusion in the review were broad and focused on any exercise-based intervention used to treat adult dysphagia from any primary etiology. We also included articles trialing exercise therapies in healthy adults without dysphagia. To meet final inclusion criteria for dosing specifications, articles had to report at least the *frequency* and the *duration* of exercise. Articles that reported detailed information on all four components of dose were considered to be "gold standard" articles and are noted in the tables (see Results). Full text articles not available to us were excluded from review. Articles were not included if the resistance exercise treatment was supplemented with an additional stimulation treatment (e.g. neuromuscular stimulation, thermal or gustatory stimulation techniques) because stimulation involves a different dosing mechanism than exercise alone. However, for articles that compared the effects of neuromuscular stimulation to a non-stimulated exercise condition, data from the exercise-only group were included in our final results. Articles were excluded from review if they reported exercise interventions lasting less than 4 weeks, did not involve a resistance exercise component (e.g. range of motion or passive manipulation), reported on single case studies only, or small case series (n<10). Optimal durations for exercise treatment programs have not been well defined in limb or cranial muscles [1, 32], and thus we chose a 4-week minimum treatment duration to allow inclusion of respiratory muscle training programs, which are usually 4 weeks in length [35].

Data abstraction was performed for all included articles by both the first and second author (BNK, LMR). Data regarding dosing recommendations (frequency, intensity, repetitions, duration), populations studied, and exercise-based treatment effects on primary outcome(s) with reported statistical findings (p-values) were recorded and are represented in Tables 1–7. Throughout abstract review and data abstraction, if there was disagreement, the first and second author reached a consensus.

Results

A total of 72 articles met final inclusion criteria.

Exercise Type and Study Population

Articles were grouped into tables based on the type of exercise program:

Table 1) 20 articles reporting combination exercise programs (2 or more specific exercise approaches) [36–55]

Table 2) 16 articles reporting tongue exercise [56–71]

Table 3) 13 articles reporting head lift (Shaker) exercise [72–84]

Table 4) 6 articles reporting respiratory muscle strength training (RMST) [85–90]

Table 5) 7 articles reporting mandible exercises [91–97]

Table 6) 5 articles reporting lip muscle training [98–102]

Table 7) 5 articles reporting other programs (e.g. Pharyngocise) [103–107]

Components of dose reported were variable within an intervention type, especially for combination exercise programs. Of all 72 articles that met inclusion criteria, 79% met "gold standard" criteria by including all four components of dose. The majority of articles included healthy participants (24%), participants with dysphagia resulting from stroke (25%), or participants with head and neck cancer (25%).

As shown in Table 1, combination exercise programs were the largest group (28%), and included a wide range of tasks such as tongue exercise (tongue press, tongue resistance, tongue elevation, tongue hold, tongue mobility), head lift exercise (Shaker), effortful swallows, supraglottic swallows, jaw exercise, and pharyngeal exercise. Most programs defined the exercises in their regimens (85%), while the others (15%) used more general terminology such as “swallow exercise,” or “therapeutic intervention for swallowing,” but did not list actual exercise procedures.

For specific exercise categories, respiratory muscle strength training, mandible exercises, and lip muscle training groups had the most consistent dose reporting, with all articles in these categories reporting all four components of dose. Most articles reporting tongue exercise and head lift met “gold standard” criteria as well, with the exception of two articles in the tongue exercise category [60, 68] and one article reporting head lift [80]. The “other programs” category included articles that did not fit into the discrete or combination exercise categories found in Tables 1–6 (see Table 7), with all but two articles [106, 107] meeting “gold standard” criteria.

Components of Exercise Dose

Exercise dose components were grouped and are discussed here by exercise type (represented in Tables 1–7).

Frequency was described by all exercise programs in this review, per final inclusion requirements. For combination exercise programs, frequency varied from as much as 7x/day for 7 days/week to as little as 3x/day for 3 days/week. Head lift exercises and tongue exercise had the most consistent recommendations for frequency across all treatment types. For head lift, 3x/day for 7 days/week was used most often (54%). For tongue exercise, 3x/day for 3 days/week was used most often (31%). All articles that incorporated respiratory muscle strength training (RMST) used a frequency of 5x/day for either 5 or 6 days a week (100%). Mandible exercises were performed 2–3x/day for 7 days/week in 5/7 articles. Lip muscle training occurred 3x/day for 7 days/week for all 5 articles (100%). “Other” category of exercise programs varied greatly, ranging from 1x/day for 1 day/week to as many as 4x/day for 7 days/week, depending on the program.

Repetitions were described in 85% of combination programs, 94% of tongue exercise, 92% of head lift, and all respiratory muscle strength training articles (100%). Repetitions were described in all mandible, lip muscle training, and the “other” exercises category (100%). For combination exercise programs, the most commonly reported set of repetitions was 10, but other repetition counts included 15 and 5. For head lift exercise, 30 lifts were recommended for isokinetic exercise (lift and lower) and 3 sustained lifts were recommended for isometric exercise (hold); when head lift exercises were incorporated into a combination exercise program, these dosing specifications for repetitions were consistently used. Tongue exercise repetitions ranged from 5 times to as many at 120 reps in a single session, but most consistently included 30 repetitions per day (38%). RMST consistently recommended 5 repetitions (100%). For isotonic/isokinetic mandible exercises, over half studied effects of 30 repetitions (57%) with more varied for isometric (hold) exercises. Lip muscle training described 3 repetitions per session most frequently (80%). The “Other” exercise program category had highly variable repetition numbers, with all 5 articles reporting different numbers.

Intensity was described in over half (55%) of the combination exercise programs, all but one tongue exercise and head lift (94% for both), all RMST (100%), all mandible (100%), all lip (100%), and more than half of "Other" programs (60%). When a device was not used to provide objective information on resistance (e.g. IOPI, RMST, or other device), intensity was described as the duration of a sustained hold (e.g., for tongue press or Mendelsohn maneuver). Other articles used more qualitative descriptors, such as "as hard as possible" or "maximum effort".

Duration was included in all exercise programs in this review per inclusion requirements and had the widest spread across any category. For combination exercise programs, the longest duration was 11 months post chemoradiation therapy. Head lift exercise duration ranged from 4–8 weeks. Tongue exercise duration ranged from 4–12 weeks. RMST duration was between 4–8 weeks. Mandible exercise duration was between 4 weeks up to 1-year post chemoradiation therapy. Lip exercise duration was between 4 weeks and 6 months. "Other" exercise programs reported durations that ranged from 4 weeks to 6 months.

Outcomes

Primary outcomes of each study were expressed as treatment effects with statistical comparisons of either a control group, another treatment group, or change in outcome from pre- to post-exercise within one group. Of all the articles in this review, 41 used comparison to control/sham or other exercise group, 29 used a pre-post analysis of the exercise group, and 2 articles used a unique statistical analysis [41, 72].

Primary outcomes measured in the articles contained in this scoping review were highly variable. Methods used for deriving outcomes were also broad (please refer to Tables 1–6, "Primary Outcome(s)" column to see a complete list).

Combination Exercise Articles

The most commonly reported outcomes in the combination exercise articles included grade of oral intake [36, 37, 41, 55], and measurements of change on videofluoroscopy using either the Penetration Aspiration Scale [37, 44, 45, 108] or another rating method [39, 42, 48, 49, 51, 52]. Other outcomes included percutaneous endoscopic gastrostomy (PEG) tube dependence[36, 37], lingual pressure measurements [40, 53], or rating scales (i.e. MD Anderson Dysphagia Inventory) [38, 39, 42, 47, 48, 53, 54]. All but three articles [42, 46, 53] reported at least 1 significant finding in the outcome(s) measured following the combination exercise program. However, as shown in Table 1, it was not apparent that improvements in various outcome measures following combination exercise programs were attributable to use of particular treatment doses.

Tongue Exercises

The primary goal of tongue exercise is to increase peak lingual pressure generation [109]. However, the effects of tongue exercise on tongue pressure during swallowing, penetration, aspiration of material into the airway, and amount of residue in the oropharynx were also studied [109]. All 16 tongue exercise articles reported on changes in lingual pressure generation anteriorly, posteriorly, or both. All articles except one [58] found significantly increased tongue pressure after tongue exercise (p≤0.05), regardless of differences in exercise repetitions, frequencies, and treatment durations. One study compared various tongue exercise intensities, but did not find a difference among training levels at 60%, 80% or 100% of a 1 repetition maximum (1RM) over 8 weeks [70]. Airway invasion, as measured using the Penetration Aspiration Scale [108] on videofluoroscopy, was an outcome in 5 articles [57, 64–66, 71]. Only one study [57] found any significant improvement in airway invasion after 4 weeks of tongue exercise. This study used 5 tongue presses per session and was not facilitated by a device. Further, this study used fewer presses per session than many of other tongue exercise articles, which typically reported at least 30 presses per session (see Table 2). The other 4 articles did not find any significant impact on airway invasion after tongue exercise at any dose. Five articles examined residue, using a variety of techniques to quantify location and amount [57, 64–66, 71]. Of these, 2 articles [57, 65] found significant decreases in residue after a course of tongue exercise. Neither of these articles included a control or sham condition. Accordingly, it is unclear whether these findings resulted from tongue exercise alone or another factor.

Head Lift Exercises

The purpose of the head lift exercise (Table 3) is to improve opening of the upper esophageal sphincter by increasing movement of the hyolaryngeal complex upward and forward [110]. Given the goals of this exercise, the three most common outcome measures used in 13 articles targeted were changes in hyoid bone movement [72, 74, 76, 77, 79], suprahyoid muscular activation [78, 81, 84], and UES opening [72, 74, 76, 77]. For changes in hyoid excursion, 3 out of 5 found significantly increased hyoid movement (anteriorly) [72, 74, 79], but 2 articles did not [76, 77]. Most of these articles used the same or a similar protocol for head lift exercise [72, 74, 76, 77]. Suprahyoid activation was significantly increased after exercise in 2 out of 3 articles, with no significant treatment effects in the study with the least frequently prescribed exercise frequency (1x/day; 2 days/week) [84]. Anterior-posterior opening of the UES was significantly greater in 3 out of 4 articles [72, 76, 77].

Respiratory Muscle Strength Training

In dysphagia treatment, the goals of RMST are to improve swallow function by increasing respiratory muscle strength, because respiration and swallowing actions are highly coordinated [35]. Swallowing outcomes in the RMST articles included in this review were particularly broad. The most common measure was the Penetration Aspiration Scale (PAS) [108], reported in over half of the articles [85–88], with only 3 of the 4 reporting a significant improvement in PAS score [85–87]. Other outcomes were Modified Barium Swallow Impairment Profile [111] (MBSImP) components [85, 88], UES opening and closure [87], and the SWAL-QoL [87, 90] with mixed findings across articles. As shown in Table 4, all articles that reported an exercise frequency of 5x/day for 5 days/week found that at least 1 or more swallowing outcome improved with treatment. However, an increase in frequency did not yield greater improvements in swallowing outcomes, as indicated by the lack of significant changes reported in a study using a 5x/day for 6 days/week [90] regimen. This result could be due to the unique study population (Huntington’s Disease), or aspects of its methodology [90]. This was the only study that included both inspiratory and expiratory training, and intensity was set to 30% of maximum at baseline, with increases of 15% every month [90]. Intensities in all other articles ranged from 60% - 75% of maximum expiratory capacity.

Mandible Exercises

These exercises included jaw opening, jaw closing, and chin tuck against resistance (CTAR). Four out of 7 of articles that examined mandibular exercises were published within the last four years. One study [93] measured chin tuck strength, jaw opening strength, tongue strength, muscle volume, and changes in videofluoroscopy and found significant changes in all but the videofluoroscopy parameters. Another article reported significant weight gain after 1 year of CTAR and TheraBite therapy 3x/day at 7 days/week [92]. Two articles [95, 96] examined effects of jaw opening exercise on hyoid movement and reported significant increases in hyoid elevation ($p<0.05$). Other articles in this category looked at Penetration Aspiration Scale (PAS) [108] ratings [94, 97], laryngeal elevation and epiglottic closure [91]. Articles in this category had a wide range of methodologies in treatment administration and outcome measurement, making it difficult to make comparisons regarding exercise dosing and statistical findings.

Lip Muscle Training

Lip muscle training is used in rehabilitating oral function after stroke, and has also been used to facilitate improvements in swallowing outcomes [99]. The principles behind IQoro® lip muscle training are based on neuroplasticity, which is different from many of the muscle strength based approaches in these other dysphagia treatments [99–101]. The two articles using the IQoro® training method with stroke patients focused on outcomes related to facial activity testing and swallowing function [99, 100], both showing significant improvements in "swallowing capacity" (amount of water swallowed, mL/s) and "oropharyngeal motor function" (not specified), respectively. Dose methods in these articles were very similar, with the largest variation being in duration of treatment, ranging from 4 weeks to 6 months. Articles reporting shorter treatment durations of 4–8 weeks [98, 102] found significant changes in lip force and "eating behavior," which may indicate that changes from this treatment may occur within shorter periods of time.

Other Exercise Articles

Outcomes for the "other" category included tracking hospitalizations for pneumonia [103], anatomical landmark changes with swallowing (i.e. UES opening, laryngeal excursion) [104], Functional Oral Intake Scale (FOIS)[112] scores [105], and measurement of muscle size and composition using MRI techniques [106]. All five articles reported positive and significant changes in these individual swallowing outcomes following their interventions. Because of the different exercises and outcomes reported in these articles, comparisons related to dosing and outcomes are not possible across treatments.

Discussion

The purpose of this scoping review was to: 1) examine the dysphagia literature to provide the range of resistance-based dysphagia exercise doses reported in peer-reviewed publications, and 2) demonstrate the importance of dose consideration in our exercise-based dysphagia treatments. Our broad search resulted in inclusion of 72 articles. While this review involved a complete literature search of four databases, it was not a systematic review because article inclusion was not limited by aspects of research design, such as evidence level achieved, number of participants included, and other considerations operationally defined in a rigorous systematic review [10]. Given the wide variability in treatment methods reported across articles, and the variety of outcomes reported, it was not possible to determine the "best" or "most effective dose" of resistance exercise for the treatment of dysphagia.

To achieve the first aim of this review, we provided an overview of the articles that reported at least the frequency and duration of exercise in their methods to create a record of exercise doses found in the research literature. We found that there are a wide range of doses and outcome measures reported in the dysphagia exercise literature. Within individual treatment categories, some components are more homogenous than others. For example, in the tongue exercise category, most articles reported 3x/day for 7 days/week for exercise frequency with 30 repetitions. For respiratory muscle strength training, articles often reported doses of 5x/day for 5 days/week, 5 sets of 5 repetitions, and 60–75% maximal expiratory capacity. However, across categories, duration and intensity were varied overall. This record clearly demonstrates the lack of agreement in dose prescription across interventions in our field.

In relation to our second aim, findings suggest that a broad discussion of methodological considerations in dysphagia treatment research is necessary to allow for discovery of the most effective exercise doses for different treatments and patient groups, as well as adequate comparison of study outcomes. Controlled studies that test and clearly report exercise doses are needed to allow development of guidelines that improve reproducibility in dysphagia research. This is an important consideration in delivery and reimbursement of speech-language pathology services. For example, through Medicaid, speech-language pathology treatments must be "reasonable [and have the] appropriate amount, frequency, and duration of treatment in accordance with standards of practice" [113]. The findings of this review demonstrate a clear need to better define these characteristics of exercise dosing to allow demonstration of treatments that are medically necessary and that will provide patients with adequate benefits to ensure best practice.

Findings from this review demonstrated a large breadth in reported dosing methodology in dysphagia research as a whole. While some interventions, such as the head lift maneuver, had more consistently reported dosing components, the majority of treatments had a wide range of reported frequencies, repetitions, intensities, and durations. For combination studies, the range of exercises and doses was very widespread. With so many combinations of exercises and various doses reported, it is likely difficult for the dysphagia clinician to identify an optimal dose for use with a particular patient. Although we did not perform a formal quality appraisal as a part of this scoping review, we did require at least exercise frequency and duration to be reported, at a minimum, for inclusion. While many of the included articles reported all four components of dose (79%), there is concern regarding the reproducibility of the remaining articles, either for research or clinical use. Omission of even one parameter integral to reproducing the exercise condition, or a lack of detail in description of exercise methodology and outcomes measured could prevent study replication. Without this information explicitly reported, it is difficult to compare and interpret the relative effectiveness of treatment regimens between articles. Therefore, we must ensure that we sustain a high level of scientific rigor in reporting of study methodology by providing detailed information about all four components of dose, and specifics on how an exercise intervention was carried out. These descriptions should also include measures of patient performance or adherence, which are critical factors to ensuring reproducibility and validity of comparisons across future articles.

Another area that emerged as a concern in quality and reproducibility was outcome selection. As we reported in the results, there are a wide range of outcome measures selected and reported for various articles within the same treatment type (See "Primary Outcomes" in Tables 1–7). This lack of uniformity in outcome selection prevents us from performing any meta-analyses or true comparisons between different dose prescriptions. Even in the case where PAS scores are reported across multiple articles, there are various methods that can be used to evaluate videofluoroscopic swallow studies to obtain these ratings. This makes direct comparison of findings even among these articles using PAS ratings more difficult, especially if videofluoroscopic protocols are not well described (i.e. bolus type, order, administration, size) or the method of generating ratings differs between articles (e.g. average of PAS score across swallows, vs "worst" PAS score across swallows). Some articles developed their own outcome measurement (i.e. swallowing capacity or "Water Swallowing Test") that are not used broadly in dysphagia literature. The problem of outcome/assessment selection was apparent in this study, and should be considered when interpreting these dose-related findings for clinical practice or future research.

Limitations in the Literature

In evaluating the research literature examining exercise-based dysphagia interventions, we noted that many articles did not provide a detailed account of the exercise methodology used in their studies. When designing and reporting human subjects research studies, researchers should provide sufficient detail to allow replication and thus must report, at a minimum, basic information such as details of participant selection, interventions used, outcomes assessments and a rationale for their selection, sample size and statistical methods, and if appropriate, blinding and randomization [114]. These guidelines have been clearly articulated in the Consolidated Standards of Reporting Trials (CONSORT), which can be adapted to any number of research designs [114]. We encourage researchers in our field to use these guidelines not only during manuscript preparation to guide methods reporting, but early in study development to ensure scientific rigor.

Conclusion

Exercise approaches available to the dysphagia clinician might include resistance exercise, neuromotor exercise, or flexibility exercise (stretching). The ACSM recommends dose prescription for these exercise categories that are outlined in Table 8. While the ACSM guidelines provide a starting point toward development of dosing criteria in dysphagia treatment, these recommendations may not be entirely applicable to dysphagia treatment, given anatomical and functional differences between spinal motor systems and the upper aerodigestive tract [115]. More systematic, high quality studies of varying exercises doses across exercise-based dysphagia treatments are required to improve our evidence base regarding dose recommendations. A consensus among dysphagia clinicians and researchers can then be reached to standardize dosage parameters for exercise treatments across care settings. In general, it is unlikely that there is a singular optimal exercise dose for each specific exercise protocol. It is more probable that optimal dosing for a specific exercise will differ depending on the patient's age, sex, comorbidities, primary etiology, physical fitness, and other factors. [116] The continued exploration of how different components of dysphagia exercise dose can be altered to maximize benefit for different individuals with dysphagia is required to improve clinical protocols for the wide range of people who are treated for dysphagia. The development of exercise-training programs that can be readily modified or tailored to target specific population(s) will be required to maximize outcomes. [116]

In future work on dysphagia exercise dose, we encourage researchers to consider these components of exercise dose (frequency, repetitions, intensity, duration) when designing and reporting on exercise-based treatment methods. For clinicians seeking to engage in evidence-based practice for dysphagia therapy, the tables provided that summarize the current evidence can serve as a reference point when developing patient-specific treatment plans. Regardless of the challenges that exist related to differentiating dose recommendations in these resistance-based exercise programs, continued work in this area is critical for continued refinement of current practices to provide our patients with the highest level of evidence-based care.

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Appendix

PubMed

((((((((((tongue[tw] AND (pressure*[tw] OR resistance[tw] OR hold*[tw] OR lift*[tw] OR strength*[tw]))))) OR (effortful swallow*[tw] OR shaker exercise*[tw] OR mendelsohn maneuver*[tw] OR supraglottic swallow*[tw] OR exercise*[tw]))) AND (((deglutition disorders[mh] NOT gastroesophageal reflux[mh]) OR (deglutition disorder*[tw] OR dysphagia[tw] OR swallowing disorder*[tw] OR swallowing difficult*[tw])))))))

Scopus [Embase]

(((TITLE-ABS-KEY (tongue) AND TITLE-ABS-KEY (pressure* OR resistance OR hold* OR lift* OR strength*)) OR (TITLE-ABS-KEY (“effortful swallow*” OR “shaker exercise*” OR “mendelsohn man*” OR “supraglottic swallow*” OR exercise*))) AND (TITLE-ABS-KEY (“deglutition disorder*” OR dysphagia OR “swallowing disorder*” OR “swallowing difficult*”))) AND (INDEX (embase))

CINAHL

((tongue AND (pressure* OR resistance OR hold* OR lift* OR strenth*)) OR ((“effortful swallow*” OR “shaker exercise*” OR “mendelsohn man*” OR “supraglottic swallow*” OR exercise*))) AND ((“deglutition disorder*” OR dysphagia OR “swallowing disorder*” OR “swallowing difficult*”))

Cochrane CENTRAL

((tongue AND (pressure* OR resistance OR hold* OR lift* OR strenth*)) OR ((“effortful swallow*” OR “shaker exercise*” OR “mendelsohn man*” OR “supraglottic swallow*” OR exercise*))) AND ((“deglutition disorder*” OR dysphagia OR “swallowing disorder*” OR “swallowing difficult*”)) in Title, Abstract, Keywords in Trials’

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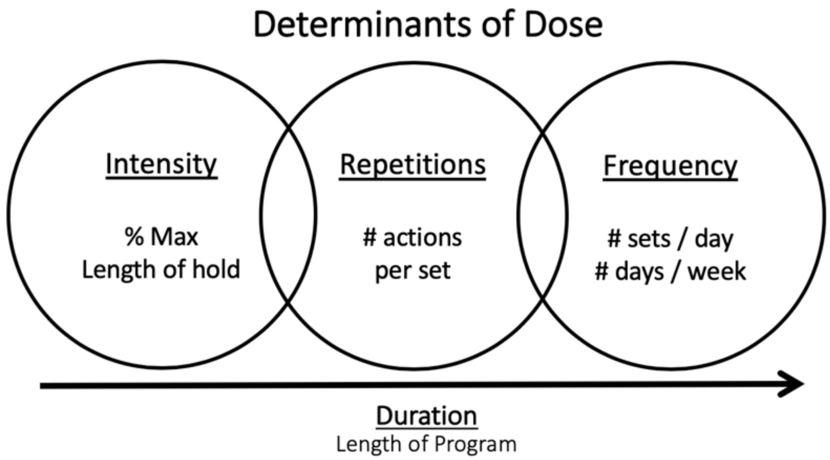

Fig. 1.

Determinants of dose in dysphagia specific exercise-based interventions

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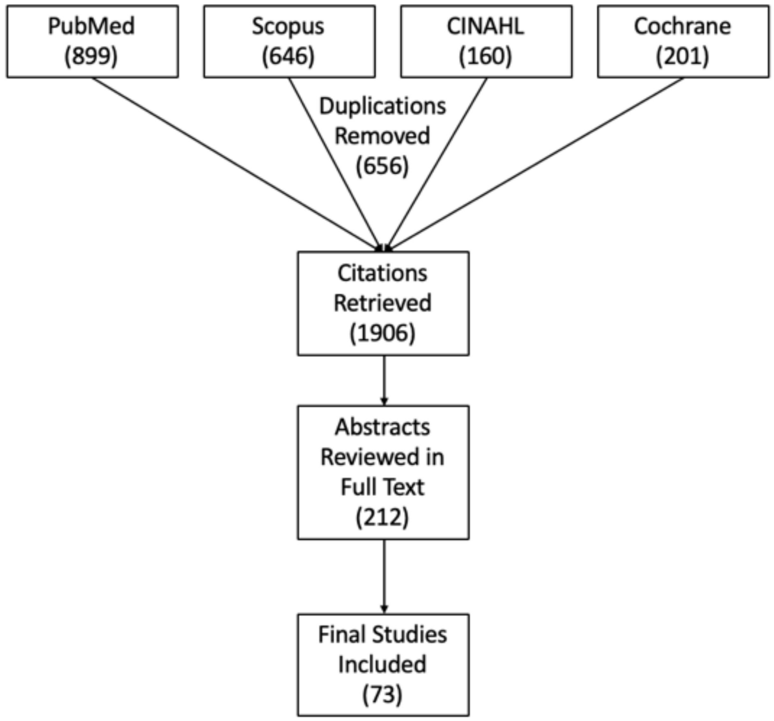

Fig. 2.

Flow chart demonstrating abstract search and review

Table 1.

Combination Exercise Programs.

Combination Exercise Programs								
GS (*)	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
	7×/day 7 days/week	Masako = 10 Pharyngeal Squeeze = 10 aShaker = X Saliva Swallows = X	X	1.5 – 1 month (during tx for HNC)	Virani (2015) #28	Head and Neck Cancer	Percutaneous Endoscopic Gastrostomy (PEG) tube dependence was lower at 3 months posttreatment	p=0.011
*	*5×/day 7 days/week*	Tongue Resistance = 1× (for 4 positions) Tongue Hold = 10 Effortful Swallow = 10 Mendelsohn = X Shaker = 30	Tongue Resistance = hold 5s Tongue Hold = X Effortful Swallow = "squeezing forcibly" Mendelsohn = hold 5s Shaker = hold 1 min, 1 min rest	2 weeks prior to CRT vs 3 months post CRT	Carroll (2008) #29	Head and Neck Cancer	Outcomes from Videofluoroscopy:	
							Penetration-Aspiration Scale Score	p=0.86
							Posterior Tongue Base at rest, during swallow, movement	p=0.071, 0.025, 0.70
							Vertical hyoid position at rest, during swallow, movement	p=0.77, 0.99, 0.77
							Epiglottic inversion	p=0.02
							Cricopharyngeal opening	p=0.81
							PEG tube use 12 months after CRT	p=0.63
		Mendelsohn = 10 Tongue Hold = 10 Tongue Resistance = 10 aShaker = 30 (sustained and repetitive)	X	2 weeks prior RDT - 6 weeks during	Kulbersh (2006) #30	Head and Neck Cancer	MD Anderson Dysphagia Inventory (MDADI):	
							Global Assessment	p=0.0002
							Emotional	p=0.005
							Functional	p=0.114
							Physical	p=0.005
		X	X	8 weeks	Millichap (2005) #31	Globus Sensation	Glasgow and Edinburgh Throat Scale (GETS)	p<0.001
							Videofluoroscopy ratings	p=not significant
*	*3×/day 7 days/week*	10 repetitions per group of each assigned exercise	Group 1 (effortful swallow only): Max effort elevation Group 2 (effortful swallow + tongue	4 weeks	Clark (2014) #32	Healthy	Maximum Isometric Lingual-palatal Pressure	p=0.002

Combination Exercise Programs								
GS (*)	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
			elevation): Max effort elevation + swallow as hard as possible Group 3 (straw sips + effortful swallow): high resistant straw sips + swallow as hard as possible					
*		Gargling = 10 Effortful Swallow = 10 Mendelsohn = 10 Chug-a-lug = 1 Tongue Protrusion = 10 Tongue Press = 10 [b]Shaker = 3	Gargling = 10s Chug-a-lug = 3oz at once	During treatment + 2 months post	Duarte (2013) #33	Head and Neck Cancer	Diet change (step up or step down in diet - PEG, liquid, puree, chewable) between "compliant" and "noncompliant" patients 1 month post-treatment	p=0.025
*		Range of Motion = 10 Tongue Hold = 10 Gargle = 10 Jaw exercise = 10 Larynx Range of Motion =10 Shaker = 30 repetitive, 3 sustained	Range of Motion = hold 1s Tongue Hold = 2 cm tongue out of mouth + swallow Gargle = 10s Jaw exercise = open as much as possible Larynx Range of Motion = hold breath 1 s Shaker = hold 1 min, rest 1 min for sustained	1 week prior to RT – 11 months post	Mortenson (2015) #34	Head and Neck Cancer	Swallowing Performance Status Scale (SPSS) from Videofluoroscopy	p=0.14
		Effortful Swallow = 15 Mendelsohn = 15	X	3 months	Tang (2011) #35	Head and Neck Cancer	Percentage of patients with "excellent" and "effective" results on the "water swallow test"	p=0.02
		Targeted Swallowing Practice – personalized 60 swallows, Sets of 20, 3×/day	X	4 weeks	Malandraki (2016) #36	Neurogenic Dysphagia	Penetration-Aspiration Scale Score	p<0.05
*		ROM Exercises = X Resistance Exercise for Tongue = 10	Range of motion = extend as far as possible and hold 1–2 s Tongue Resistance = push tongue against a blade for 5 s	12 weeks	Hsiang (2019) #37	Head and Neck Cancer	Penetration-Aspiration Scale Score	p=0.037
*	*2×/day* *7 days/week*	Tongue Mobility = 5 Mendelsohn = 10	Tongue Mobility = as far out as possible Mendelsohn = 2–3s hold	During RDT and 3 months post	Ahlberg (2011) #38	Head and Neck Cancer	Weight loss (change in weight from diagnosis to 6 months after treatment)	p=0.4

Combination Exercise Programs								
GS (*)	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
							2-Year survival	p=0.49
*		Tongue Resistance = 10 Effortful Swallow = 10 Masako = 10 Mendelsohn = 10 Shaker = 10	See Full Text for Descriptions	8 Weeks	Carmignani (2018) #39	Head and Neck Cancer	Physical Scale of Dysphagia Handicap Index *3 months post CRT/RT	p=0.039
*		Therabite = passive range of motion exercises performed 7 repetitions, (performed 7 times per day, instead of 2) Lip protrusion/retraction = 10 Lingual ROM and strength exercises = 10 Pharyngeal strengthening = 5 – 10	See Full Text for Descriptions	During CRT and 3 months post	Messing (2017) #40	Head and Neck Cancer	Dysphagia Outcome Severity Scale	p=0.29
							Oral phase impairments	p=0.13
							Pharyngeal phase impairments	p=0.007
	1×/day 7 days/week	"Exercise program with oral, pharyngeal, laryngeal and respiration exercises" (X)	X	2 months	Kang (2012) #41	Stroke	"New VFSS Scale" (Jung et al. 2005[d])	
							Total score (oral stage)	p<0.05
							Total score (pharyngeal stage)	p=not significant
*	*2x/day 6 days/week*	Super-Supraglottic = 10 Regular Swallows= 10 Mendelsohn = 10 Effortful Swallow = 10	"Work muscles hard" for all	12 weeks	[c] Langmore (2015) #42	Head and Neck Cancer	Penetration-Aspiration Scale scores on VFSS (sham group only)	p<0.001
	2×/day 5 days/week	Sustained vowel phonation = 10 Ascending and descending gliding phonations = 5 Rotating tongue in oral vestibule = 5	X	5 weeks	Argolo (2013) #43	Parkinson Disease	Loss of bolus control	p<0.03
							Piecemeal swallow	p=0.05
							Residue on tongue	p<0.01
							Residue in valleculae	p=0.01
							Residue in pyriform sinuses	p=0.05
		Effortful dry (saliva) swallow Tongue protrusion Tongue rollback Each exercise = 2 per set / 25 sets per session (total = 50 reps of each exercise/session)	X	12 weeks	Wang (2018) #44	Parkinson's disease	Piecemeal deglutition	p=0.001
							Pre- and Post-swallow respiratory phase pattern	p=0.042
							Swallowing respiratory pause	p=0.178
							Onset latency	p=0.541
							Total excursion time	p=0.117

Combination Exercise Programs								
GS (*)	Frequency	Repetitions	Intensity	Duration	1st Author (Year) Citation #	Population(s) Studied	Primary Outcome(s)	p-Value(s)
							Second deflexion of laryngeal excursion	p=0.420
							Amplitude of submental sEMG	p=0.165
							Amplitude of laryngeal excursion	p=0.039
*	*2×/day 3 days/week*	Resistance tongue exercise = 10 reps; Head flexion exercise = 10 reps	10s each	3 months	Wakabayashi (2018) #45	Community Dwelling Individuals with Dysphagia	Eating Assessment Tool 10 (EAT-10)Scores	p=0.665
							Mean Tongue Pressure	p=0.376
		"Traditional Dysphagia Therapy" Exercise programs, pharyngeal swallowing maneuvers, compensatory strategies, sensory stimuli listed in Table 1	X	6 weeks	Tarameshlu (2019) #46	Multiple Sclerosis	Mann Assessment of Swallowing Ability	p<0.001
		Effortful Swallow + Mendelsohn (X)	"Squeeze as hard as you can with all your throat muscles"	5.3 weeks	Li (2016) #47	Stroke	Change in Functional Oral Intake Scale (FOIS)	p=0.004

GS = Gold Standard

[a]Specifies 3×/day; 7 days/week for Shaker exercise

[b]Specifies 1×/day; 7 days/week for Shaker exercise

[c]Sham Neuromuscular stimulation (NEMS) group only /swallow treatment group alone, review does not include NEMS group

[d]Jung SH, Lee KJ, Hong JB, Han TR. Validation of clinical dysphagia scale: based on videofluoroscopic swallowing study. J Korean Acad Rehab Med 2005; 29: 343–350

X indicates that article did not list specific exercise types and/or intensity/instructions for execution of exercise; HNC = Head and Neck Cancer; Tx= therapy; RDT = Radiation Therapy; CRT = Chemoradiation Therapy; RT = Radiation Therapy; sEMG = surface electromyography; PEG = Percutaneous Endoscopic Gastrostomy; reps = repetitions; ROM=range of motion

Table 2.

Tongue Exercise.

Tongue Exercise								
GS (*)	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
*	5×/day 7 days/week	Isometric Strength = Anterior and Posterior - 6 reps per location Isometric Accuracy = 3× (1× at 50, 60, 100%)	Isometric Strength = not specified Isometric Accuracy = 50, 70, 100%	8 weeks	Moon (2018) #48	Subacute Stroke	Iowa Oral Performance Instrument Measurements	p<0.05
							Swallowing Quality of Life Assessment (SWAL-QoL)	p<0.05
							Mann Assessment of Swallowing Ability (MASA)	p<0.05
*	2×/day 7 days/week	5× per session	Press tongues against palate for 10s, followed by 10s rest	4 weeks	Namiki (2019) #49	Presbyphagia	Anterior Hyoid Movement	p=0.031
							Superior Hyoid Movement	p=0.012
							Tongue Pressure	p=0.002
							Width of UES	p=0.001
							NRRSp	p=0.022
							Penetration-Aspiration Scale Score	p=0.016
*	*5×/day* *5 days/week*	10× per session	"Press as hard as possible" for 2 seconds	6 weeks	Lazarus (2014) #50	Head and Neck Cancer	Head and Neck Cancer Inventory (A: Speech, B: Eating, C: Social disruption)	A: p=1.000 B: p=0.347 C: p=0.650
							Head and Neck Cancer Inventory (A: Speech, B: Eating, C: Social disruption) – within-group	A: p=0.128 B: p=0.028 C: p=0.161
							Oropharyngeal Swallowing Efficiency Score (experimental pre-post)	p=0.351
							Tongue strength (pre-post)	p=0.571
							Salivary flow (within and between groups)	p=Not significant
*		5 sets of 10 repetitions, minimum rest of 30sec between sets (50 presses anterior and posterior)	80% 1RM		Park (2015) #51	Stroke	Videofluoroscopic Dysphagia Scale (O: Oral, P: Pharyngeal, T: Total)	O: p<0.01 P: p<0.05 T: p<0.01
							Maximum Tongue Pressure (A: Anterior, P: Posterior)	A: p<0.01 P: p<0.01

Tongue Exercise								
GS (*)	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
	1×/day 5 days/week	30× per session for anterior and posterior	X	4 weeks	Kim (2017) #52	Stroke	Videofluoroscopic Dysphagia Scale (O: Oral, P: Pharyngeal, T: Total)	O: p=0.029 P: p=0.007
							Maximum Tongue Pressure (A: Anterior, P: Posterior)	A: p=0.009 P: p=0.015
							Penetration-Aspiration Scale Score	p=0.471
*		Isometric = 3× Isotonic = 30×	Isometric = 10s hold Isotonic = 2s	6 weeks	Park J-S (2019) #53	Healthy Young Adults	Thickness of mylohyoid	p=0.037
							Thickness of digastric	p=0.042
*	*3×/day 5 days/week*	10× per session	"Push the tongue firmly onto the palate, while squeezing neck muscles, swallow as forcefully as possible"	4 weeks	Park H-S (2019) #54	Stroke	Anterior Tongue Strength	p=0.046
							Posterior Tongue Strength	p=0.042
							Oral Phase of Swallowing	p=0.017
*	*3×/day 3 days/week*	10× per session	"Push hard [against alveolar ridge] for 3 seconds"	4 weeks	Park T. (2016) #55	Healthy Older Adults	Maximum Tongue Pressure	p=0.001
							Normalized peak amplitude of submental sEMG	p=0.474
*		30× per session	Week 1: 60% of 1RM Weeks 2–7: 80% of 1RM Re-measure maximum at weeks 2, 4, 6	8 weeks	Robbins (2005) #56		Lingual Peak Isometric Pressures (week 4, week 6)	Wk4: p=0.002 Wk6: p=0.001
							Swallowing Pressures (A: 3mL effortful, B: 3mL thin, C: 10mL thin, D: 3mL semi-solid)	A: p=0.001 B: p=0.18 C: p=0.04 D: p=0.01
							Videofluoroscopic Outcomes (Penetration-Aspiration Scale Score, bolus flow duration, residue, swallow kinematics)	p=Not significant
*		30× (at anterior and posterior sensors)			Robbins (2007) #57	Stroke	Maximum Isometric Tongue Pressure (A: Anterior, P: Posterior) at 8 weeks	A: p<0.001 P: p<0.001
							Swallowing Pressures (A: 3mL effortful, B: 3mL thin, C: 10mL thin, D: 3mL semi-solid)	A: p=0.53 B: p=0.004 C: p=0.03 D: p=0.02
							Oropharyngeal residue (A: 3mL effortful, B: 3mL thin, C: 10mL thin, D: 3mL semi-solid)	A: p=0.02 B: p=0.01 C: p=0.02 D: p=0.07

Tongue Exercise								
GS (*)	Frequency	Repetitions	Intensity	Duration	1st Author (Year) Citation #	Population(s) Studied	Primary Outcome(s)	p-Value(s)
							Penetration-Aspiration Scale Scores (A: 3mL at week 4, B: 10mL at week 8)	A: p=0.005 B: p=0.003
							5. SWAL-QoL Questionnaire (F: Fatigue, C: Communication, M: Mental)	F: p=0.047 C: p=0.026 M: p= 0.22
*		30× per session			Rogus-Pulia (2016) #58	Older Adults with Dysphagia (Multiple Etiologies)	Anterior and Posterior Lingual Pressures	p<0.001
							Penetration-Aspiration Scale Scores	p=0.14–1.0
							Oropharyngeal Residue	p=0.16–0.99
							Pneumonia Diagnosis	p=0.10
							Hospital Admissions	p=0.009
							Bed Days	p=0.17
*		30 per session	Week 1: 60% of 1RM Weeks 2–7: 80% of 1 RM Re-measure maximum at weeks 2, 4, 6	8 weeks	Yano (2019) #59	Healthy Young Adults	Anterior & Posterior Tongue Pressure	
							Completion of Training	p=0.023 & p=0.041
							After 1 month	p=0.041 & p=0.023
							After 2 months	p=0.023 & p=0.023
							After 3 months	p=0.023 & p=0.023
	1x/day *3 days/week*	X	60% for week 1, and 80% thereafter (weekly update of 80% maximum)	8 weeks	Oh (2015) #60	Healthy Young Adults	Outcomes at 8 Weeks:	
							Tongue Tip Pressure	p=0.000
							Tongue Base Pressure	p=0.000
							Effortful Swallowing Pressure	p=0.000
							Outcomes After 28 Weeks Detraining:	
							Tongue Tip Pressure	p=0.004
							Tongue Base Pressure	p=0.001

Tongue Exercise								
GS (*)	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
							Effortful Swallowing Pressure	p=0.000
*		Anterior Tongue Press (Group 1) Posterior Tongue Press (Group 2) 5 reps per set, 24 sets per 1 session (120 tongue tasks/day)	30s rest in between each of the 5 repetitions, Hold pressure for 3s, 80% of 1 RM, *recalculated every 2 weeks	8 weeks	Van den Steen (2018) #61	Healthy Elderly Adults	Maximum Isometric Pressure - Anterior	Anterior group > posterior group (p=0.000)
							Maximum Isometric Pressure - Posterior	Both groups increased (p=0.000)
*		120 presses per day (60 anterior and 60 posterior) – divided into 24 sets of 5, 30s rest after each set	3 Groups 1. 60% 1RM 2. 80% 1RM 3. 100% 1RM	8 weeks	Van den Steen (2019) #62	Healthy Elderly Adults	Differences in Maximum Isometric Pressure between Intensity Groups	p=Not significant
*	*1×/day 2–3×/week*	(Two protocols: TPPT and TPSAT) 45–60 total reps across tongue pressure and saliva/ bolus tasks for strength and/or accuracy. Each exercise 5–20 reps.	Max Isometric Pressure: 85%, or randomized 25–85% based on protocol Saliva: natural, or effortful	8–12 weeks (24 sessions total)	Steele (2016) #63	Stroke	Maximum Isometric Posterior Tongue Pressure	p<0.001
							Stage Duration (Thin Liquids)	p=0.13
							Penetration-Aspiration Scale Score	p= Not significant
							Normalized Residue Ratio Scale (Thin, Nectar)	p=0.05 thin p=Not significant nectar

GS = Gold Standard

X indicates that article did not list specific exercise types and/or intensity/instructions for execution of exercise; GS = Gold Standard

Abbreviations: TPPT = tongue-pressure profile training, TPSAT = tongue-pressure strength and accuracy training, MIP = Maximum isometric pressure, RM = 1 repeated maximum contraction, sEMG = surface electromyography, SWAL-QoL = swallowing quality of life; MASA = Mann Assessment of Swallowing Ability; NRRSp = Normalized Residue Ratio Scale Pyriform Sinus; UES = Upper Esophageal Sphincter; PAS = Penetration Aspiration Scale; 1 RM = 1 rep maximum; kPa= kilopascals; sEMG = surface electromyography

Table 3.

Head Lift Exercises.

Head Lift Exercises								
GS (*)	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
*	3×/day 7 days/week	30 repetitions for isokinetic set 3 repetitions for isometric set	Hold 1 minute	6 weeks	Easterling (2005) #64	Healthy Older Adults (non-dysphagia)	Videofluoroscopy Biomechanics Outcomes:	
							Maximum Anterior Hyoid Excursion	$p < 0.05$
							Maximum Anterior Laryngeal Excursion	$p<0.05$
							Maximum Anteroposterior UES Deglutitive Opening	$p<0.05$
							Superior Hyoid and Laryngeal Movements	$p>0.05$
*		Shaker: 30 head lifts, or 3 sustained head lifts CTAR: 30 reps, or 3 sustained 1 minute holds Traditional Therapy: 10× per each tongue exercise/ direction	Head Lift and CTAR: isokinetic, or 1 minute hold Tongue exercise: not defined	6 weeks	Gao (2017) #65	Cerebral Infarction	Penetration-Aspiration Scale: Pre-Post Shaker (4 week, 6 week)	$p<0.0$
							Penetration-Aspiration Scale: Pre-Post CTAR (4 week, 6 week)	$p<0.05$
							Penetration-Aspiration Scale: Shaker vs. CTAR (4 week, 6 week)	$p<0.05$
							Self-Rating Depression Scale: CTAR vs. Shaker (within-group	$p=0.00$
							Self-Rating Depression Scale: CTAR vs. Shaker and Control	$p<0.05$
*		30 reps for isokinetic set 3 for isometric set	Hold 1 minute for isometric set	6 weeks	Fujiki (2019) #66	Healthy Older Adults	Superior Hyoid Excursion	$p\leq0.001$
							Anterior Hyoid Excursion	$p=0.0088$
							Upper Esophageal Sphincter Opening	$p=0.1322$
*					Mishra (2015) #67	Healthy Young Adults	Swallow Duration	p= not significant[a]

Head Lift Exercises								
GS (*)	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
							sEMG peak amplitude (within and between groups)	p=0.579, p=0.715
							Within Group Lingual Isometric Strength	p=0.03
							Between-Group Lingual Isometric Strength	p=0.892
							Perceived Exertion (within-group, between-groups)	p<0.001, p=0.317
*					Shaker (2002) #68	Tube-Fed Patients with Abnormal UES Opening (Multiple Etiologies)	Anteroposterior Diameter of UES Opening	p<0.001
							Anterior Laryngeal Excursion	p<0.05
							Functional Outcome Assessment Measure of Swallowing (Assigned, Crossover subjects)	p<0.001 p<0.05
							Superior Laryngeal Excursion, Anterior and Superior Hyoid Excursions, Lateral Diameter of UES Opening	p=Not significant[a]
							Pyriform Sinus Residue	p<0.01
*					Shaker (1997) #69	Healthy Older Adults	Maximum Anterior Laryngeal Excursion	p<0.05
							Anteroposterior Diameter of Maximum UES Opening	p<0.05
							UES Cross-Sectional Area	p<0.05
							Max Superior and Anterior Hyoid Excursions, Max Superior Laryngeal Excursion, Max Lateral UES Diameter	p= not significant[a]

Head Lift Exercises								
GS (*)	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
							Intrabolus Pressure	$p<0.05$
*	*Group 1: 1×/day 7 days/week Group 2: 3×/day 7 days/week*				Woo (2014) #70	Healthy Young Adults	Suprahyoid Muscle Activation (Within-Group)	$p<0.01$
							Infrahyoid Muscle Activation (Per Group)	2. $p<0.05_{(Grp1)}$ $p<0.01_{(Grp2)}$
*	*1×/day 5 days/week*	Head Lift: 30 reps isokinetic 3 reps isometric Conventional Dysphagia Therapy: not specified	Head Lift: Hold 1 minute Conventional Dysphagia Therapy: Not defined	4 weeks	Park, J-S (2017) #71	Stroke	Hyolaryngeal Kinematics:	
							Hyoid Movement (A: Anterior, S: Superior)	A: p=0.005 S: p=0.003
							Laryngeal Movement (A: Anterior, S: Superior)	A: p=0.014 S: p=0.039
							Between-Groups	p=0.044 Superior Hyoid; p=not significant for all other kinematics.
							PAS (L: Liquid, S: Solid) Within-Group	L: p=0.004 S: p=0.004
							PAS (L: Liquid, S: Solid) Between-Groups	L: p=0.044 S: p=0.667
	1×/day 3 days/week	X	X	6 weeks	Don Kim (2015) #72	Stroke	ASHA NOMS	$p<0.05$
							New VFSS Scale (Total Score)[b]	$p<0.05$
							Between Group Differences in ASHA NOMS and New VFSS	p=Not significant[a]
*		1 swallow every 10 seconds for 10 minute blocks / 2 minute breaks, over 20 minutes.	Head maximally extended back Comfortable swallow	8 weeks	Oh (2016) #73	Healthy Young Adults	Suprahyoid Muscle Activation During Effortful Swallowing	p=Not significant[a]
							Suprahyoid Muscle Activation During Effortful Swallowing (8 weeks, Follow-up)	p=0.016 p=0.917
							Isometric Tongue Pressure at 8 weeks, and	A: p=0.022, p=0.843

Head Lift Exercises								
GS (*)	Frequency	Repetitions	Intensity	Duration	1st Author (Year) Citation #	Population(s) Studied	Primary Outcome(s)	p-Value(s)
							Follow-Up (A: Tip, B: Base)	B: p<0.001, p=0.197
*	*3×/day 2 days/week*	Shaker: 30 for isokinetic, 3 for isometric Traditional swallow exercise: 5 times for all exercises	Shaker: 60 sec isometric hold Traditional swallow exercises: 1 sec each	6 weeks	Mepani (2009) #74	Head and Neck Cancer, and Cerebrovascular Accident	Maximum Thyrohyoid Muscle Shortening (between-groups)	p=0.034
							Maximum Thyrohyoid Muscle Shortening (within-groups)	p=0.066 Shaker p=0.48 Other
*	*1×/day 2 days/week*	60 repetitions (extending head back + saliva swallow)	10 minutes swallowing every 20s, 2 min break, then repeat (22 total minutes); head extended back maximally looking at ceiling	8 weeks	Oh (2018) #75	Healthy Elderly Individuals	Suprahyoid muscle activation during effortful swallowing	p=0.002
							Tongue Tip Pressure	p=0.014
							Tongue Base Pressure	p=0.004
							Normal Swallowing Pressure	p=0.046
							Effortful swallowing pressure	p=0.009
							Tongue tip endurance	p=0.004
							Thickness of digastric muscle	p=0.00
							Thickness of genioglossus muscle	p=0.004
*			*Same as above, only with head extended back at 30 degrees instead of maximally	8 weeks	Oh (2019) #76	Healthy Young Individuals	Tongue Pressure-Related Parameters & Suprahyoid Activation	p=Not significant pre vs. post training

GS = Gold Standard

[a] Indicates value not reported

[b] Jung SH, Lee KJ, Hong JB, Han TR. Validation of clinical dysphagia scale: based on videofluoroscopic swallowing study. J Korean Acad Rehab Med 2005; 29: 343–350

X indicates that article did not list specific exercise types and/or intensity/instructions for execution of exercise; GS = Gold Standard

Terms: isokinetic = consecutive head lifts at a constant velocity, performed without holding or rest periods, isometric = sustained hold

Abbreviations: CTAR = chin tuck against resistance, SDQ-J = swallowing disturbance questionnaire –Japanese version, ALSFRS-R = Amyotrophic lateral sclerosis rating scale – revised, SWAL-QOL = swallowing quality of life, QMG = Quantitative Myasthenia Gravis, PAS = Penetration-Aspiration Score, PNF = proprioceptive neuromuscular facilitation, VFSS = Videofluoroscopic swallow study; ASHA NOMS = American speech-language-hearing association national outcomes measurement system; UES = upper esophageal sphincter; sEMG = surface electromyography

Table 4.

Respiratory Muscle Strength Training.

Respiratory Muscle Strength Training								
GS (*)	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
							Outcomes from Videofluoroscopy:	
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	60% of Maximal Expiratory Pressure (updated once per week to advance)	5 weeks	Hegland (2016) #77	Stroke (Ischemic)	Total MBSImP pharyngeal components score[a]	p<.001
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	60% of Maximal Expiratory Pressure (updated once per week to advance)	5 weeks	Hegland (2016) #77	Stroke (Ischemic)	Rosenbek Penetration-Aspiration Score	p=0.057
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	60% of Maximal Expiratory Pressure (updated once per week to advance)	5 weeks	Hegland (2016) #77	Stroke (Ischemic)	Individual MBSImP component scores	p=0.709
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	4 weeks	Pitts (2009) #78	Parkinson Disease	Rosenbek Penetration-Aspiration Score	p=0.01
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	4 weeks	Troche (2010) #79	Parkinson Disease	Rosenbek Penetration-Aspiration Score	p=0.001
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	4 weeks	Troche (2010) #79	Parkinson Disease	SWAL-QoL	p=0.007
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	4 weeks	Troche (2010) #79	Parkinson Disease	Onset of bolus transport	p=0.058
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	4 weeks	Troche (2010) #79	Parkinson Disease	UES opening	p=0.009
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	4 weeks	Troche (2010) #79	Parkinson Disease	UES – widest area	p=0.006
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	4 weeks	Troche (2010) #79	Parkinson Disease	UES closure	p=0.007
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	4 weeks	Troche (2010) #79	Parkinson Disease	Laryngeal closure	p=0.082
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	4 weeks	Troche (2010) #79	Parkinson Disease	Maximum laryngeal closure	p=0.091
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	4 weeks	Troche (2010) #79	Parkinson Disease	Laryngeal opening	p=0.068
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	8 weeks	Hutcheson (2018) #80	Head and Neck Cancer	DIGEST	p=0.03
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	8 weeks	Hutcheson (2018) #80	Head and Neck Cancer	Penetration Aspiration Scale (PAS)	p=0.59
*	*5×/day 5 days/week*	5 sets of ×5 repetitions/day	75% of Maximal Expiratory Pressure (level set once, at baseline)	8 weeks	Hutcheson (2018) #80	Head and Neck Cancer	MDADI	p=0.13

Respiratory Muscle Strength Training								
GS (*)	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
							MBSImP	p>0.05
*		5 breaths per set, 5 sets / day	70% Maximal Expiratory Pressure, 1 min break in between sets	4 weeks	Park J-S (2017) #81	Healthy Elderly Individuals	Buccinator muscle	p<0.05
							Orbicularis oris muscles	2. p<0.05* (intervention and sham)
*	*5×/day 6 days/week*	5 sets of ×5 repetitions/day (Inspiratory and Expiratory)	30% of Maximal Inspiratory/Expiratory Pressure (respectively) at baseline, progressively increased by 15% resistance every month for a target of 75% (thresholds were re-assessed every 2 weeks)	4 months	Reyes (2015) #82	Huntington's Disease	SWAL-QoL	d=0.54
							Outcomes from 50mL Water Swallowing Test[b]	
							Time Per Swallow(s)	d=0.58
							Swallowing Capacity (mL/ second)	d=0.50
							Swallowing Flow (mL)	d=0.38

GS = Gold Standard

[a]MBSImP (Modified Barium Swallow Impairment Profile) pharyngeal components: Initiation of pharyngeal swallow, soft palate elevation, laryngeal elevation, anteriohyoid excursion, epiglottic movement, laryngeal vestibule closure, pharyngeal stripping wave, pharyngoesophageal segment opening, tongue base retraction, pharyngeal residue

[b]No prior studies regarding respiratory muscle strength training in Huntington's disease; unable to control for the size of type II error. Outcomes are reported as standardized effect sizes (Hedges' g).

SWAL-QoL = swallowing quality of life questionnaire; UES = upper esophageal sphincter; MDADI= MD Anderson Dysphagia Index; DIGEST = Dynamic Grade of Swallowing Toxicity; HNC = head and neck cancer; Tx = therapy; PAS = Penetration Aspiration Scale

Table 5.

Exercises involving the Mandible.

Exercises involving the Mandible									
GS (*)	**Name of Program**	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
*	Chin Tuck Against Resistance (CTAR)	*1×/day 5 days/week + "30 min/day conventional dysphagia treatment"*	Isometric = 3× Isotonic = 30×	Isometric = 60s hold Isotonic = consecutive repetitions	4 weeks	Park J-S (2018) #83	Stroke	Oral, laryngeal elevation/epiglottic closure, residue	p<0.05
*	TheraBite	*3×/day 7 days/week*	See Publication for Detail	See Publication for Detail	During CRT up to 1 year after	Molen (2014) #84	Head and Neck Cancer	Weight Gain, Other outcomes	p=0.002 Weight Gain
*	CTAR + JOAR		Isokinetic: 30× consecutively, 1s per contraction Isometric: maintained for 60sec, rest for 60sec, ×3 sets Effortful Swallow: (after 60 sec rest) 10×	CTAR + JOAR: bar pressed to chin Effortful Swallow: bar pressed to chin 50% Start intensity individualized based on dynamometry and 30sec max. Subsequent increase by self-perceived effort	6 weeks	Kraaijenga (2015) #85	Healthy Senior Subjects	Chin Tuck Strength	p=0.005
								Jaw Opening Strength	p=0.005
								Anterior & Posterior Tongue Strength	p=0.016 & 0.08
								Muscle Volume	p=0.008
								Videofluoroscopy Parameters	p=not significant
*	Swallow Exercise Aid		Chin Tuck Against Resistance & Jaw Opening Against Resistance 1. Isokinetic = 30× 2. Isometric = 3× Effortful Swallow = 10×	Chin Tuck Against Resistance & Jaw Opening Against Resistance 1. Isokinetic = 1s/contraction 2. Isometric = 60s hold + 60s rest *See publication for description of intensity Effortful Swallow = w/ chin bar compressed down 50%	8 weeks	Kraaijenga (2017) #86	Head and Neck Cancer	PAS Score for Thickened Liquid	d = 0.3
*	Jaw opening exercise	*2×/day 7 days/week*	3 sets, 20 repetitions	Rapid, maximum jaw opening, 10 s between sets	4 weeks	Matsubara (2018) #87	Mixed Diagnoses w/ Dysphagia Symptoms	Upward hyoid movement	p=0.02
								Forward hyoid movement	p=0.17
								Pharyngeal transition time	3. p=0.01

Exercises involving the Mandible									
GS (*)	**Name of Program**	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
*	Jaw opening exercise		5 jaw extensions/set	Open jaw to maximum extent and maintain position for 10s, followed by 10s rest	4 weeks	Wada (2012) #88	Reduced opening of Upper Esophageal Sphincter (UES)	Hyoid elevation	p<0.05
								UES opening	p<0.05
								Pharynx passage time	p<0.05
								Pharyngeal residue	p=not significant
*	Modified Chin Tuck Against Resistance	*1×/day* *5 days/week*	Isometric Chin Tuck = 3× Isotonic Chin Tuck = 30× + "30 min traditional dysphagia treatment"	Isometric = hold down for 10 seconds	6 weeks	Kim (2019) #89	Stroke	PAS and FOIS	p<0.001

GS = Gold Standard

CTAR= Chin Tuck Against Resistance; JOAR= Jaw Opening Against Resistance; UES=Upper Esophageal Sphincter; PAS= Penetration Aspiration Scale; CRT = chemoradiation therapy; PAS = Penetration Aspiration Scale; FOIS = Functional Oral Intake Scale

Table 6.

Lip Muscle Training.

Lip Muscle Training									
GS (*)	**Name of Program**	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
*	Lip muscle training	*3×/day 7 days/week*	3×/session (sessions before meals) using the Lip Force Meter, LF 100	Pulling for 5–10 seconds	5–8 weeks	Hagg (2008) #90	Stroke	Lip force	p<0.001
								Swallowing capacity (ability to swallow 150 ml of water in "one sweep" as quickly as possible)	p<0.001
*	IQoro® Lip muscle training		3×/session (sessions before meals)	Palatal plate group - intensity not listed Oral Iqoro screen – pulling 5–10 seconds	3 months	Hagg (2015) #91	Stroke	Effect on "four-quadrant facial dysfunction" via Facial Activity Testing	p<0.001
								Swallowing capacity (amount of water swallowed / time, mL/sec)	p<0.001
*	IQoro® Lip muscle training		3×/session (sessions before meals)	Pulling for 5–10 seconds	3 months	Hagg (2016) #92	Stroke	Oropharyngeal motor function	p<0.05
*	IQoro® neuromuscular training		3 repetitions	Pull forward for 5–10 seconds while resisting with sealed lips; 3 s rest in between each pull	6 months	Franzen (2018) #93	Patients with Hiatal Hernia and Gastroesophageal Reflux Disease	"Cough and misdirected swallowing"	Reduced in obese patients p<0.01
*	Lip Closure Training		1 repetition, 3 times a day	Hold lips closed for 3 minutes	4 weeks	Takamoto (2018) #94	Healthy Elderly Adults	"Eating Behavior" – time to eat per mouthful	p<0.05

GS = Gold Standard

Table 7.

Other Exercise Programs.

Other Exercise Programs									
GS (*)	**Name of Program**	**Frequency**	**Repetitions**	**Intensity**	**Duration**	**1st Author (Year) Citation #**	**Population(s) Studied**	**Primary Outcome(s)**	**p-Value(s)**
*	Vocal Exercise Method (Glottal Closure)	*4×/day 7 days/week*	10 (counting up from 1 to 10)	Increased glottal closure by increasing vocal intensity	6 months	Fujimaki (2017) #95	Patients with "glottal closure insufficiency"	Hospitalizations for pneumonia	See paper
*	Swallow Resistance Exercise Device	*3×/day 7 days/week*	30 Saliva Swallows, 15 second intervals	0–2 Weeks: 20 mm Hg resistance 2–4 Weeks: 20–30 mm Hg resistance 4–6 Weeks: 40 mm Hg resistance	6 weeks	Agrawal (2018) #96	Healthy Senior Subjects	Maximum Upper Esophageal Sphincter Opening	p<0.01
								Superior and Anterior Laryngeal Excursion	
								Posterior Pharyngeal Wall Thickness	
								Increase in Deglutitive Pharyngeal Contractile Integral	
*	Mendelsohn	*In Clinic: 1×/week (20 minute sessions) until improvement, then bi-weekly* *At Home: 2–3×/day, 7 days/week*	1 repetition every 30 seconds for 20 minutes (40–60 reps/day)	Sustained laryngeal hold for 8–10sec	*In Clinic:* Average 7 sessions *At Home:* average 76.1 days	Bogaardt (2009) #97	Stroke	Functional Oral Intake Scale	p<0.01
	"Pharyngocise"	*2×/day 7 days/week*	10 repetitions of 4 swallowing exercises over 4 cycles	X	6 weeks (max during CRT)	Carnaby-Mann (2012) #98	Head and Neck Cancer	Muscle size and composition determined by T_2-weighted MRI	
								Genioglossus	p<0.01
								Mylohyoid	p<0.017
								Hyoglossus	p<0.037
	Cognitive Behavioral Therapy + Swallowing Exercises	*1×/day (40–60min)* *1 day/week (or every other week)*	"Individualized swallowing exercises" + 45 –60 minutes of cognitive behavioral therapy	X	Up to 10 sessions (1 session weekly or bi-monthly)	Patterson (2018) #99	Head and Neck Cancer	See paper	See paper

GS = Gold Standard

X indicates that article did not list specific exercise types and/or intensity/instructions for execution of exercise; GS = Gold Standard

MRI = Magnetic Resonance Imaging

Table 8.

Exercise Recommendations adapted from the American College of Sports Medicine and other sources.

Type of Exercise	Definition	Frequency	Repetitions	Intensity	Duration
Resistance Exercise	Exercises that involve concentric and eccentric muscular contraction with the goal of improve muscular strength and power	2–4×/day; 2–3× days/week	8–12 for most adults, 10–15 for middle-aged and older adults, 15–20 for improvement of muscular endurance (which may be of particular interest to the dysphagia clinician)	-Novice to intermediate: 60–70% of 1-RM - Experienced: ≥ 80% of 1-RM for experienced -Older Individuals: 40–50% 1-RM -To improve muscular endurance: <50% 1-RM -Older individuals to improve power: 20%-50% 1-RM	Specific duration of training has not been definitively determined according to these guidelines. However, a systematic review[a] of resistance exercise in older adults showed that most programs are between 8 and 12 weeks.
Neuromotor Exercise	Exercises that involve motor skills such as coordination and agility, which may be impaired in dysphagia from neural insult	20–30 minutes/ day, 2–3 days/ week	Repetitions, Intensity, Duration are not well defined for this type of treatment according to ACSM guidelines. However, there is a systematic review[b] that lists repetitions, intensity, and duration for studies included in their review that may be useful to reference. The overall conclusions of this study were not definitive due to varied findings and quality of evidence found during review of resistance-based neuromotor exercise. It is likely that consensus on this is difficult due to the wide range of neurological conditions that exist and the heterogeneity of individuals in the various disease categories, making this difficult to study.		
Flexibility Exercise (Stretching)	Joint range of motion or flexibility	2–4×/each exercise, ≥2–3 days/week with daily being most effective	10–30s static stretch time is recommended for most adults, 30–60s for older adults,	Stretch to the point of slight discomfort (feeling muscle tightness)	Not specified

Table adapted from the American College of Sports Medicine’s (ACSM) Guidelines for Exercise Testing and Prescription: Medicine ACoS: ACSM’s guidelines for exercise testing and prescription: Lippincott Williams & Wilkins, 2013.

1-RM = 1 Rep Maximum

[a] Latham NK, Bennett DA, Stretton CM, Anderson CS: Systematic review of progressive resistance strength training in older adults. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences 59: M48-M61, 2004.

[b] Cup EH, Pieterse AJ, Jessica M, Munneke M, van Engelen BG, Hendricks HT, van der Wilt GJ, Oostendorp RA: Exercise therapy and other types of physical therapy for patients with neuromuscular diseases: a systematic review. Archives of physical medicine and rehabilitation 88: 1452–1464, 2007.