Exercise-Based Approaches to Dysphagia Rehabilitation

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Abstract

Rehabilitative techniques for dysphagia (swallowing impairment) increasingly employ exercise modeled on methods used to train muscles in sports medicine. Three techniques in particular show promise for improving muscle strength and function related to swallowing: the Shaker exercise, expiratory muscle strength training, and tongue pressure resistance training. All three techniques invoke principles of task specificity, muscular load, resistance, and intensity, and aim to achieve functional changes in swallowing through changes in muscle physiology derived from strength or endurance training. To date, studies of treatment benefit arising from these techniques involve small sample sizes; this is particularly true of randomized studies with controls receiving standard treatment or experiencing spontaneous recovery. Nevertheless, a review of the available literature shows that improvement of penetration-aspiration is a common finding for individuals with dysphagia receiving one of these three treatment approaches. Although hypothesized as an expected outcome of swallow muscle strength training, improvements in post-swallow residues are noted to be uncommon as an outcome of these exercise-based approaches. The available evidence suggests that exercise-based approaches to swallowing rehabilitation do succeed in changing muscle strength and function, but generalization to true swallowing tasks may be somewhat limited.

The field of dysphagia diagnosis and intervention is relatively young, with current practices dating back to the pioneering work of Logemann, whose first textbook was published in 1983 [1]. Prior to the publication of that book, the dysphagia literature was dominated by studies profiling swallowing impairment seen in a variety of specific etiologies, and by descriptions of protocols for the radiological examination of swallowing function. Beginning in the 1980s,
studies describing techniques for dysphagia intervention emerged. These early techniques fell exclusively into the category of compensatory interventions, that is, interventions that are intended to yield an immediate but transient improvement in swallowing function, provided that the technique is used correctly. Examples of compensatory interventions include the use of thickened liquids and food texture modifications to manipulate the flow of material through the pharynx. Other compensatory interventions are behavioral techniques that must be learned by the patient. Postural modifications such as chin down or head turn are intended to change the configuration of the oropharynx so that the bolus can be contained in the mouth without spilling, collects in the vallecular space in the case of spillage, and flows effectively through the hypopharynx and upper esophageal sphincter (UES). Different postures are indicated for different types of impairment; for example, a head turn is described to direct the bolus away from the side of weakness in a patient with unilateral pharyngeal paresis, thereby utilizing the stronger and intact muscles on the unimpaired side [2]. Other behavioral techniques involve volitional efforts to enhance airway closure or hyolaryngeal excursion, such as the supraglottic swallow and the Mendelsohn maneuver. A final class of compensatory interventions involves stimulation techniques, intended to heighten sensory input and evoke a more timely and effective swallow motor response. Thermal tactile stimulation is probably the best known of these techniques, described to yield improvements in swallow transit times, but subsequently shown to have only a transient, time-limited effect [3–5]. Later studies exploring other modalities of stimulation, such as taste, have shown similar, transient effects [6].

Around the mid-1990s, discussions emerge in the literature regarding the possibility that some dysphagia interventions might have the potential for longer-lasting effects, i.e. to effect permanent changes in swallowing physiology. These techniques became known as rehabilitative interventions and were described as ‘interventions that, when provided over the course of time, are thought to result in permanent changes in the substrates underlying deglutition; i.e., changing the physiology of the swallowing mechanism’ [7]. An important distinction regarding rehabilitative interventions is that it is intended that the patient will not need to remember to use the technique whenever they swallow. The goal is to restore functional swallowing that does not require compensation.

A number of the previously described compensatory interventions have been recognized to have possible rehabilitative potential, if practiced in a rigorous and repetitive manner. Stimulation techniques including thermal, electrical, air pulse and transcranial magnetic methods are currently under investigation for their potential to elicit neuroplastic changes in swallowing motor control [8–13]. With respect to behavioral techniques, Kahrilas et al. [14, 15] describe a patient who learned to use the Mendelsohn maneuver to overcome difficulties in UES opening and regained swallowing function. Similar stories were reported for case series of patients with long-standing pharyngeal and UES impairment.
by Crary et al. [16, 17] and Huckabee and Cannito [18]. These studies were among the first to train patients to perform swallowing exercises over the course of at least 10 treatment sessions, scheduled regularly (i.e. daily or twice daily), and involving multiple task repetitions within each treatment session. Such protocols resemble the kinds of exercise regimens used in the gym for cardiac fitness, muscle strengthening or weight loss training. That is, they involve many repetitions of a task, ideally performed at a difficulty level that will lead either to skilled task performance through learning and/or to changes in the muscles that are challenged during the task. However, it is known that changes in muscle tone, strength and bulk are unlikely to be achieved without consideration of exercise load, resistance, intensity and duration. Burkhead et al. [19] argues that similar considerations need to be applied to rehabilitative swallowing exercises.

Several different examples of swallowing interventions are candidates for use in an exercise-based protocol. Some have been studied, showing proof-of-principle that repeated practice over a 6–8-week time frame can indeed lead to changes in swallowing physiology. For example, the Shaker exercise is a head-lifting technique performed in the supine position, and intended to specifically exercise the suprahyoid muscles. Gravity provides a source of fixed resistance, and the exercise is performed in both an isometric (sustained) and isokinetic (short repetitions) manner [20]. The Shaker exercise is indicated for patients who display impaired UES opening, given the recognition that excursion of the hyolaryngeal complex is biomechanically linked to UES opening. By improving the strength of the muscles responsible for superior and anterior hyolaryngeal excursion in swallowing, the technique aims to facilitate greater UES opening and reduced UES pressures. Preliminary data from healthy adults who practiced this technique support these hypotheses, as do results from patients who have performed the Shaker exercise compared to those performing a sham exercise [20, 21]. Penetration-aspiration has also been reported to improve in these patients.

A second example of an exercise-based approach to dysphagia intervention is expiratory muscle strength training (EMST), originally developed for patients with respiratory difficulties and voice disorders [22]. Patients are required to do forced exhalation through a device that provides resistance to expiratory airflow. Varying degrees of resistance can be set in the device, and patients are instructed to do 20 min of practice daily over 4 weeks. Early work with this exercise suggested that the suprahyoid muscles become engaged during expiratory threshold training tasks [23], lending support to the idea that the technique might have benefits for swallowing. Two recent studies in individuals with Parkinson’s disease have shown improvements in penetration-aspiration and in hyoid movement following 4 weeks of EMST [24, 25].

Perhaps the most-studied form of exercise training for dysphagia is resistance training for the tongue. The rationale for strength training of the tongue dates back to studies documenting reduced pressures on maximum isometric
tongue-palate press tasks in healthy older adults [26]. An important point about these findings is that age-related declines are not seen in swallowing pressures, which utilize less than half of each person's maximum tongue pressure capacity. Nevertheless, given the observation of reduced maximum tongue pressures and other literature suggesting atrophy in tongue and neck muscles similar to that seen in sarcopenia of the leg muscles, Robbins et al. [27] designed an 8-week program of repetitive tongue pressure resistance exercise. In this program, participants perform 60 tongue-palate presses each day, on alternate days of the week, for a total of 24 sessions over 8 weeks. The exercises in each session are distributed evenly between anterior and posterior tongue-palate presses, and an important component of the program is the identification of a target work zone, or load, for each patient, between 60 and 80% of their maximum capacity. Repeated measurement of maximum capacity each week allows for incremental super-stepping of the target zone. Healthy seniors who followed this regimen showed a 20% increase in maximum isometric pressures versus baseline [27]. This provided the preliminary evidence to justify application of the technique in patients with dysphagia.

In 2007, Robbins et al. [28] published the results of a preliminary case series study of tongue pressure resistance training in stroke patients with dysphagia. These individuals were described to have an average penetration-aspiration scale score of 6 (aspiration below the true vocal folds) on 10-ml swallows of thin liquid barium at baseline, and their maximum isometric tongue pressures fell below 40 kPa – the range reported to be normal for older men. After 8 weeks of tongue pressure resistance training, pressure capacity had increased by 46% for anterior-, and by a dramatic 81% for posterior-emphasis tasks. Importantly, penetration-aspiration scale scores also improved in this group, with the post-treatment mean falling at 1 (i.e. no penetration or aspiration). Robbins et al. [28] also monitored other components of swallowing function in videofluoroscopy. Despite the improvement in penetration-aspiration, no systematic improvements in residue were observed in this patient group. It should be recognized that these patients, who were in the first 6 months following stroke, may have enjoyed some spontaneous recovery. The degree to which the treatment may be responsible for the observed improvements is unclear.

In our lab at the Toronto Rehabilitation Institute we have been interested in tongue pressure resistance training, but challenged by the data showing that swallowing is a task that does not utilize a person's full tongue pressure capacity. We have been particularly interested in the role played by the tongue in controlling thin liquid bolus flow, and speculated that this requires a precise matching of applied tongue pressure to the inherent viscosity or flow characteristics of a bolus in order to achieve the desired result. Our prior work in studying tongue movements and tongue pressure generation in swallowing strongly suggests that tongue pressures build during the time when the body of the tongue is raised and pressing forward along the palate [29]. These anterior-superior pressures
are thought to generate squeezing forces that move liquid boluses backwards through the mouth towards the pharynx (fig. 1). In cases where insufficient pressure is applied, particularly by the back of the tongue, it seems likely that a very low-viscosity liquid will spill into the pharynx under its own inertia. A thicker consistency might not be effectively propelled, leaving oral and pharyngeal residues.

Based on these ideas, we hypothesized that the ability to achieve precise pressures, and to vary pressures to match bolus viscosity, might be important for bolus
control. The analogy here is that the tongue might be doing something similar to what the hand and arm do, when trying to manage to balance an upright pole without it falling, except that in the case of swallowing, the task requires both balancing and transporting the liquid bolus in a controlled manner. Therefore, we designed a modification to the Robbins protocol, in which the target zone for practice involved a series of variable pressure targets, falling between 20 and 90% of the patient’s maximum values. The task is analogous to hitting a series of different bull’s-eye targets precisely with darts, rather than lifting incrementally heavier weights. In practice, this involves the speech-language pathologist measuring maximum pressure capacity across a series of 5 maximum isometric pressures at the beginning of the treatment session (e.g. mean of 30 kPa), and then randomly choosing submaximal values, which the patient tries to generate with accuracy (e.g. 15, 22, 27, etc.) during therapy. Feedback regarding accuracy in reaching the target pressure without overshoot or undershoot can be provided based on pressure amplitude readings on hand-held manometers such as the Iowa Oral Performance Instrument. As in the Robbins protocol, each treatment session involves 60 tongue pressure training tasks, distributed equally between those emphasizing anterior tongue-palate pressure and posterior tongue-palate pressures.

Our first 3 patients demonstrated different patterns of change with this treatment, described in a previous publication [30]. One patient, within 6 months after cortical stroke, showed rapid gains in maximum strength across the first 12 sessions of treatment, and then plateaued. Another patient, 4 years after skull base tumor resection, in which the hypoglossal nerve sustained iatrogenic injury, showed very little change in the first 12 sessions of treatment, but then showed rapid gains from session 12 to 24. This pattern suggests that individuals with chronic injury may require longer courses of treatment in order to respond. A third patient, 4 years after brainstem hemorrhage, showed no change in tongue pressure capacity across 24 sessions of treatment, but elected to continue training, with remote monitoring, for a total of 1 year (138 sessions) of treatment. He showed very slow improvement, but eventually reached a maximum isometric tongue pressure of 40 kPa around session 90, showing further gains beyond that point, as illustrated in figure 2. The obvious tongue weakness and slow initial recovery in this patient may be partially attributable to a Botox injection that had been administered to his submandibular area in order to limit oral secretions; this injection contributed to increased dysarthria and may, therefore, have impacted his tongue muscles. However, our data suggest that even with chronic atrophy and putative neurotoxin-induced peripheral injury, tongue pressure resistance training can be used to build tongue muscle strength and pressure generation capacity. Such gains appear to be seen both when treatment emphasizes strength targets between 60 and 80% of maximum and when the emphasis is placed on variable pressure accuracy between 20 and 90% of maximum.

Following these early pilot results, we have continued to investigate tongue pressure strength and accuracy training in individuals with neurogenic
dysphagia. We have worked with an etiologically heterogeneous group including patients with dysphagia following stroke, acquired brain injury, or skull base tumor resection, and also with frail elders with neurologic conditions like Parkinson’s disease. The common thread among these individuals has been evidence of poor oral bolus containment with thin liquids on videofluoroscopy. We have conducted a controlled case series in individuals who have all completed 24 sessions of treatment with pre- and posttreatment videofluoroscopy. Results of that study are currently in the process of publication, but demonstrate similar findings to those of Robbins et al. [28], namely improvements in penetration-aspiration scale scores with thin liquid stimuli, but no systematic improvements in pharyngeal residues with spoon-thick stimuli.

The persistence of pharyngeal residues following all three of the different approaches to exercise-based dysphagia intervention that we have reviewed (Shaker exercise, EMST, tongue pressure resistance training) suggests that we have not yet found treatment tasks that have adequate specificity for the process of pharyngeal bolus clearance.

In conclusion, exercise-based interventions require careful design, with attention to task selection and specificity, load, intensity and treatment duration. To date, there is preliminary evidence that penetration-aspiration can be reduced through exercise-based interventions in neurogenic dysphagia.
References


