Critical Review:
The effectiveness of tongue strengthening on swallowing function in adults with dysphagia

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This critical review examines the evidence regarding the impact of tongue strengthening on swallowing function in adults with dysphagia. Study designs include: one case series, three single subject designs, one mixed randomized clinical trial and one case study. Results of the examined studies revealed suggestive evidence that tongue strengthening can improve swallowing function in adults with dysphagia. Further research is required in larger, homogeneous participant samples in order to determine if treatment effects can be generalized.

Introduction

Dysphagia refers to an impairment or disorder of the process of deglutition (swallowing) affecting the oral, pharyngeal and/or esophageal stages of swallowing (CASLPO PSG, 2007). Dysphagia occurs as a secondary consequence to neurogenic, oncologic, surgical, congenital, structural, psychogenic and/or iatrogenic pathologies (CASLPO PSG, 2007). CASLPO (2007) states that more than 200, 000 people are living with dysphagia at any given time. Dysphagia places individuals at risk for aspiration pneumonia, malnutrition and dehydration and contributes to decreased quality of life (QOL) and considerable economic consequences to the health care system (CASLPO PSG, 2007).

Current dysphagia intervention includes compensatory and/or behavioural modifications. These practices can negatively impact QOL and inhibit the patient from resuming an active role in their recovery (Robbins, Kays, Gangnon, Hind, Hewitt, Gentry & Taylor, 2007). One of the most common strategies for managing aspiration risk in oropharyngeal dysphagia is texture modification (Robbins, Gangnon, Theis, Kays, Hewitt & Hind, 2005). Patients on a modified diet are more prone to dehydration and malnutrition suggesting that alternative interventions are important in the return of functional swallowing (Robbins et al., 2005).

Few intervention protocols place emphasis on the rehabilitation of the neurophysiologic underpinnings of dysphagia and instead focus on compensatory and/or behavioural strategies (Robbins et al., 2005). The aim of exercise strengthening protocols is to impact long-term rehabilitation by accessing neural plasticity and/or restoring or increasing muscle mass and strength (Robbins et al., 2005; Yeates, Molfenter & Steele, 2008).

The tongue provides the major propulsive force required for swallowing and therefore makes a significant contribution to swallowing (Robbins et al., 2005). Generating tongue pressure plays an important role in controlling bolus flow through the oral cavity and pharynx (Steele, Bailey, Cliffe Polacco, Hori, Molfenter, Oshalla & Yeates, 2013). Tongue weakness contributes to symptoms of dysphagia thus providing evidence for the implementation of tongue strengthening protocols (Robbins et al., 2005; Stierwalt & Youmans, 2007). Chances of aspiration due to pre-mature bolus spill into the pharynx and impaired bolus clearance increase when tongue pressure generation is impaired (Steele et al., 2013).

Robbins at al. (2005) demonstrated that tongue pressure generation exercises contribute to restoring tongue mass and muscle strength in older adults. Prevention or delay of dysphagia may be accomplished with tongue exercises thus reducing the health care costs associated with treating aspiration pneumonia, malnutrition and dehydration (Robbins et al., 2005). Furthermore, tongue exercises contribute to improvements in QOL for older patients and their families (Robbins et al., 2005).

Objectives

The primary objective of this paper is to critically evaluate the existing literature regarding the effects of tongue strengthening on swallowing function in adults with dysphagia. The secondary objective is to propose evidence-based recommendations for future research.

Methods

Search Strategy

The computerized databases CINAHL, Medline and PubMed were searched using the following search strategy: ((tongue) OR (lingual)) AND ((exercise) OR (strengthening)) AND ((swallowing) OR (dysphagia) OR (deglutition)). An examination of the reference section of articles yielded more articles for inclusion.

Selection Criteria

Research studies included in this critical review were required to investigate the impact of tongue strengthening on swallowing outcomes in adults with dysphagia. No limits were set on the underlying cause or severity of dysphagia. Only studies examining adults with dysphagia were included; however, no limits on other demographics were set (e.g. culture, gender, socioeconomic status).

Data Collection

Results of the literature search yielded the following 6 articles that met the selection criteria: case series (1) and single subject designs (3). Two additional articles were selected that implemented exercise training that included tongue strengthening: mixed randomized clinical trial (1) and case study (1).

The articles are rated based on The Oxford 2011 Table of Evidence. Level I designs provide the most compelling evidence and level IV and V are non-experimental designs providing the least compelling evidence.

Results

Sonies (1993) used a level IV design in her investigation of a single case study. The participant was a 63-year-old male with Von Willebrand's disease who received surgery for oral masses due to carcinoma. The participant presented with swallowing and chewing difficulty, tightness in the throat, tongue immobility, oral dryness, sleep disturbance and weight loss. An oral sensory motor exam in conjunction with an ultrasound and VFSS revealed deficits in the oral preparatory, oral, and pharyngeal phases of swallowing. Eleven problems were identified that contributed to the functional deficits and a treatment plan was established that included 6 goals. Treatment exercises included: external oral and facial sensory stimulation, internal oral sensory stimulation, exercises to improve strength and coordination of the lips and tongue as well as chewing, velar and swallowing exercises. Graded food presentation was used in regard to taste, temperature and texture. The participant was seen daily for the first month, 2-3 times per week for months 2 and 3, weekly for month 4 and then only for follow-up sessions as needed. Daily home exercises were assigned and reviewed at sessions. Treatment sessions were structured to treat a single problem and the participant continued to work on the problem until he reached 90% competence. Following 3 months of treatment total nutritional intake was taken orally, weight returned to normal and social life, vocational activities and hobbies resumed.

Strengths of the Sonies (1993) study include: a detailed explanation of treatment activities was provided allowing for replication and a thorough description of the participant's impairments and pre-treatment presentation was provided. Limitations include: lack of quantitative parameters from which to evaluate swallowing impairment, post-treatment measures were either not provided or not performed and tongue strengthening was not addressed and measured in isolation. Although a thorough description of the participant and methods was provided, this study yields equivocal evidence that tongue strengthening exercises improve swallowing function due to the comprehensive treatment program that did not target tongue strengthening in isolation and the lack of quantitative measures.

Kang, Park, Lee, Kim, Yoon & Jung (2012) used a level I design in their investigation of the effects of an exercise program conducted at bedside on the recovery of swallowing in 50 participants <6 months post-stroke. This mixed randomized clinical trial compared the control group (25 participants) that received conventional swallowing therapy to the experimental group (25 participants) that received 1 hour of exercise training per day for 2 months. A Mann-Whitney U test and chi square test were used to compare groups and no significant differences existed accounting for age, sex, swallowing capability, daily activity performance and stroke location. Both groups received tactile-thermal stimulation every day for 2 months and the experimental group underwent a program that involved oral, pharyngeal, laryngeal and respiration exercises. The following measures were conducted at baseline and post treatment: a new videofluoroscopic swallowing study (VFSS) scale, Functional oral intake scale (FOIS), frequency of dysphagia complications, transition from tube to oral feeding, Functional independent measure (FIM), Beck depression inventory (BDI) and Stroke Specific Quality of Life Scale (SS-QOL).

Non-parametric tests with a p value of 0.05 regarded as being significant were used to compare post treatment results within and between groups without providing a rationale for their use. The new VFSS scale results revealed that the experimental group exhibited significant changes in oral phase, mastication, bolus formation, apraxia and oral transit time when compared to the controls. There was no significant difference in the pharyngeal phase between the two groups. There was also no significant difference in tube feeding or incidence of aspiration pneumonia between the groups. The experimental group showed a significant improvement on the FOIS compared to the control group. BDI scores demonstrated a significant decrease in the experimental group but not when compared to the

controls. Significant improvements were revealed in the experimental group when compared to the controls on the energy, family role and mood parameters of the SS-QOL.

Kang et al. (2012) demonstrated significant differences on a number of measurements related to swallowing function in the experimental group when compared to a control group. Some limitations to the study include: relatively small sample size, tongue exercises were not targeted in isolation, patients with severe dysphasia and tracheostomies were excluded and a detailed description of the exercise protocols was lacking. VFSSs only examined one bolus condition preventing insight into swallowing function with a variety of consistencies. In addition, the program offered an indirect training method, which may have interfered with the combination of direct and indirect methods. Due to the nature of treatment, blinding was not administered. Strengths of this study include: 2 rehab specialists agreed upon VFSS results, however, no inter-rater reliability scores were reported and appropriate statistical analysis was completed. Due to the comprehensive exercise program where tongue exercises were not targeted in isolation there is only equivocal evidence that tongue strengthening protocols improve swallowing function in adults with dysphagia post-stroke.

Robbins et al. (2007) used a level III study design in their investigation of the effects of lingual exercise on swallowing recovery post-stroke. The design was a case series of 10 participants. Six participants were less than 3 months post-stroke and 4 were more than 3 months post-stroke. Participants completed an 8-week tongue strengthening protocol consisting of tongue pressure tasks in the anterior and posterior positions using the Iowa Oral Performance Instrument (IOPI). Pressure targets were set at 60% and 80% of the participant's baseline maximum pressure and readjusted throughout the treatment. The following measures were collected at baseline, week 4 and week 8: maximum isometric pressures, lingual swallowing pressures, bolus flow parameters (4 different bolus conditions) using VFSS including residue (3 point scale), Penetration-Aspiration (P/A) Scale scores (8 point scale that measures the occurrence, depth, patient response to and clearance of material invading the laryngeal vestibule or trachea) and durational measures, magnetic resonance imaging (MRI) and quality of life (SWAL-QOL) and diet questionnaires.

Two-sample t tests were used to assess the impacts of the program with a p value of $<.05$ regarded as being significant. Results revealed a significant increase in maximum isometric pressures at weeks 4 and 8 ($p<.001$). There was a significant increase in maximum swallowing pressures on at least 1 trial of 3 different bolus conditions at weeks 4 and 8. A significant reduction in residue was revealed on 3 different bolus conditions at week 8. P/A Scale scores were significantly reduced for 2 bolus conditions following 8 weeks. A significant decrease in oral transit time was observed for the 3mL liquid bolus condition ($p=.036$) and an increase in pharyngeal response time was observed for 2 bolus conditions. An increase in lingual volume was observed in 2 out of 3 participants who underwent MRI. SWAL-QOL results revealed significant changes in the fatigue, communication and mental health areas. Dietary questionnaire results revealed an addition of difficult to swallow items to the participant's diet.

Some limitations to the Robbins et al. (2007) study include: a heterogeneous sample that varied in stroke chronicity as well as location and size of lesion, a small sample size and the use of ordinal scales that may lack sensitivity to detect change. Furthermore, improved P/A scores in the absence of increased swallowing pressures provides evidence that the program modified underlying physiologic and biomechanical parameters that were not accounted for by the measures obtained in the study. Strengths of this study include: the residue scale demonstrated high inter- and intra-rater reliability, MRI demonstrated low inter-rater error and participants who were unable to complete a VFSS were given the lowest possible score on the P/A scale to preserve statistical analysis. Researchers provided a detailed description of the research design and used appropriate statistical analysis providing suggestive evidence that tongue strengthening increases swallowing function post-stroke.

Yeates et al. (2008) used a level I design in their examination of the effectiveness of tongue pressure accuracy tasks in addition to isometric strength exercises on swallowing function in older adults with dysphagia in 3 'n-of-1' studies. Participants included a 72-year-old male who was 7 months post stroke, a 63-year-old male who was 42 months post tumor resection and a 50-year-old male who was 34 months post brainstem stroke. Participants completed tongue pressure generation exercises with a speech and language pathologist (SLP) 2-3 times per week for 45-minute sessions with biofeedback from the IOPI. The protocol consisted of isometric strength exercises with the anterior and posterior tongue where the participant was required to press the bulb of the IOPI to the roof of their mouth as hard as possible. One set of isometric strength exercises was coupled with a swallow if the participant was capable of volitional saliva swallows. The remaining exercises were accuracy tasks where the

participant generated specific pressures in the anterior and posterior positions. Target pressures were set at 50%, 75%, and 100% of their maximum pressure measured during the first isometric strength exercise in the session. In total 10 sets of 6 repetitions were completed per session. Average peak pressure, accuracy and accuracy relative to strength were monitored and calculated separately for the anterior and posterior positions at each therapy session. Physiologic changes were measured using VFSSs pre, midway and post treatment. Stage transition duration time (STDT) is defined as the interval between the arrival of the head of the bolus at the ramus of the mandible and the onset of the first hyolaryngeal excursion associated with upper esophageal sphincter (UES) opening. STDT was calculated from the VFSS recordings in order to measure bolus control.

All participants demonstrated improved isometric strength across the course of therapy. With the exception of one participant's anterior values, accuracy also improved across the course of therapy. Mean STDT decreased for two participants suggesting increased bolus control. STDT could not be calculated for the third participant due to absent UES opening. However, on the latest VFSS opening of the UES was observed for the first time post injury. Oral intake increased in two participants to the extent where tube feeding was discontinued in one case.

Although Yeates et al. (2008) used a level I design, there is only suggestive evidence that tongue accuracy in addition to strengthening tasks improve swallowing function in older adults due to the limitations of the study. Limitations include: the results cannot be generalized due to the small sample size and the group was variable in etiology and chronicity of dysphagia. A detailed description of the tongue pressures and accuracy techniques was provided, however, VFSS protocols were not outlined making replication of the study difficult. Furthermore, accuracy plots were not included for 2 participants and no information was provided about the VFSS raters. The measures do not include any functional analysis, the results were primarily descriptive and no statistical analyses were conducted.

Malandraki, Kaufman, Hind, Ennis, Gangnon, Waclawik & Robbins (2012) used a level I design to examine the effectiveness of a tongue strengthening treatment program on swallowing function in a 77-year-old female with Inclusion body myositis (IBM) and Sjogren's syndrome. The study design was a single subject n-of-1 design consisting of an 8-week tongue strengthening program that was repeated 3 times over 5 years both at home and at an outpatient swallowing clinic. Maintenance periods were repeated following the second and third treatment cycles and 2 detraining periods were repeated following the second treatment cycle (preceding and following the maintenance period). The patient exercised the anterior and posterior parts of their tongue for 3 sets of 10 repetitions 3 times per day for 3 days a week. Anterior and posterior isometric lingual pressures were measured bi-weekly with the IOPI. Target pressures were set at 60% to 80% of the participant's baseline and readjusted throughout the treatment at weeks 2, 4 and 6. VFSSs were preformed at baseline, weeks 4 and 8 of the exercise program and before and after maintenance and detraining periods. Airway invasion was measured using the P/A Scale and clearance of the bolus using a 3-point scoring system.

The researchers used a regression model to fit the data, however, the parameters used to determine the statistical outcomes were unclear. Significant changes in tongue strength was demonstrated over 5 years ($p<.001$). Isometric pressures in the anterior position declined over time but the rate of decline was lower during years 4 and 5 where the participant received 2 cycles of treatment and maintenance. Posterior pressures stabilized during the second cycle of intervention with declines between the cycles of intervention. P/A scores demonstrated significant changes ($p=.03$). The score remained stable during the second cycle of intervention and worsened in the year between the second and third cycles. Following the third treatment the P/A score returned to the level of the prior year. There were no significant changes in residue scores.

Malandraki et al. (2012) demonstrated that in this participant, tongue strengthening slowed the progression of strength loss due to disease and extended functional swallowing performance. Strengths of the study include: participant compliance was calculated to be 90%, the primary caregiver was trained to use the IOPI and at weeks 2, 4, and 6 during intervention the participant received an additional session to assess placement of the IOPI and address technical problems. VFSS scoring was conducted by 2 experienced SLPs and reanalyzed by the same rater and a different rater (inter-rater and intra-rater reliability scores were less than 90% within 1 scale score). The limitations include: a single case report limits the generalizability of results, a dual diagnosis complicates interpretation of results and ordinal scales may lack the sensitivity to detect change. In addition there were missing data points during periods the participant did not return to the clinic (initially no intention to include participant in research) and inter-rater reliability data for the IOPI measurements was not collected. Due to limitations of this single case there is only suggestive evidence that tongue strengthening

protocols improve swallowing function in patients with IBM.

Steele et al. (2013) used a level I design in their examination of the outcomes of tongue-pressure accuracy and strengthening tasks in 6 adults with dysphagia secondary to acquired brain injury. The design was 6 'n-of-1' studies and included participants ranging between 5-42 months post injury. Participants completed 10 sets of 6 repetitions of maximum isometric pressure and accuracy tasks in anterior and posterior positions 2 times per week for 24 sessions using the IOPI. Accuracy targets were set between 20% and 90% of the participant's maximum isometric pressure that was calculated at each session. Saliva swallowing pressures were also documented across the course of treatment. Baseline tongue pressure range was calculated over the first 3 sessions from which subsequent performance was compared. An effect size band of d= +/-0.6 was established around the baseline to confirm the presence or absence of change. Three or more consecutive data points falling outside the effect size band were required as evidence of change in maximum isometric strength. Pre and post treatment VFSS measures included the P/A Scale to document swallowing safety and a 4-point residue scale.

Anterior isometric pressure increased (sustained above effect size boundary for 3 consecutive sessions) for 5 participants, however, 2 participants failed to maintain these gains across treatment. Posterior isometric pressure increased for all participants, however 1 participant failed to maintain these gains. Saliva swallowing pressure increased for 3 participants, however, only 1 participant maintained these gains across treatment. Improved swallowing safety was demonstrated by 4 participants on thickened liquids and by 5 participants on thin liquids. Changes in residue were less apparent with no trend of improvement. Evidence of bolus clearance worsening in some participants was demonstrated at the end of treatment.

Steele et al. (2013) demonstrated that swallowing safety improved for the majority of participants with thin liquids and for over half the participants with thickened liquids. There are some limitations of this study such as: small sample size limiting the generalizability of results, ordinal scales may lack the sensitivity to detect change and the participants varied widely in chronicity and severity of swallowing impairment. Therefore it is difficult to examine the patient profiles for which the treatment protocol is most effective. This study does, however, exhibit many strengths that include: strong inter-rater reliability and a strong effect size band to document significant change. VFSS protocols were described in detail and 3 repetitions of each bolus type were administered providing more consistent results. Furthermore, the participant's worst score on baseline VFSS measurements was documented, suggesting stronger evidence of change. The researchers provided a thorough description of the research design and used appropriate measurement techniques providing suggestive evidence that tongue pressure accuracy and strength training improve swallowing function in adults with acquired brain injury.

Discussion

Based on evaluation of the literature there appears to be suggestive evidence that tongue strengthening contributes to improved swallowing function in adults with dysphagia. Interpretation and generalization of these results must be done with caution due to the limitations of the studies. All 6 studies included small sample sizes making it difficult to generalize the results. Furthermore, the studies did not evaluate homogenous groups of participants. Yeates et al. (2008) evaluated a group of participants who were variable in their etiology and chronicity of dysphagia. Robbins et al. (2007), Steele et al. (2013) and Kang et al. (2012) evaluated participants with the same dysphagia etiology, however, participants varied in chronicity of dysphagia.

Neuroplasticity and spontaneous recovery may have contributed to improved swallowing function in all 6 studies, excluding Malandraki et al. (2012) due to the progressive nature of the participant's disease. Spontaneous recovery may be a larger factor in some of the studies due to the lack of homogeneity of participants. For example, Robbins et al. (2007) included 6 participants who were less than 6 months post-stroke and 4 who were more than 6 months post-stoke. It is likely that the participants who were less than 6 months post-stroke experienced a more substantial amount of spontaneous recovery than the participants who were more than 6 months post stroke. Therefore including all 10 participants in one group makes it difficult to generalize the results and to determine how much contribution neuroplasticity played in swallowing recovery.

Five out of the 6 studies used videofluoroscopic swallowing studies, the gold standard in dysphagia assessment in order to evaluate swallowing outcomes. Four of these studies provided a detailed description of the VFSS protocols used including the number of swallowing trials and bolus conditions. Robbins et al. (2007) used 4 bolus conditions varying in consistency and volume that were repeated 2-3 times for each participant. The remaining 3 studies did not include as many bolus conditions that varied in consistency and volume. A variety of conditions are important in order

to assess the participant's functional swallowing abilities in the natural context. In addition, 3 out of the 6 studies used a 3-point ordinal residue scale that may lack the sensitivity to detect change. A more detailed scale may provide more information resulting in the detection of smaller changes.

Recommendations

Based on the limitations listed above there is a need for further research in this field. Recommendations for future research are as follows:

- Increased sample size and control for etiology and chronicity of dysphagia. This may allow for more generalization to the larger population.
- Longitudinal studies to assess the durability of tongue strengthening and whether retraining or maintenance therapy is warranted.
- Further studies that address participant's ability to achieve precise lingual pressures and vary the pressures. Accuracy tasks in addition to strengthening tasks may be important for bolus control (Steele, 2012).
- Determine the dosage, frequency, length and timing of treatment that is appropriate for different stages and etiologies of dysphagia.
- Increased number of VFSS bolus conditions that vary in both volume and consistency. This may provide more information about the participant's ability to swallow in the natural context.
- A more descriptive residue scoring measure that has increased sensitivity to detect change.

Clinical Implications

The investigation of tongue strengthening to improve swallowing function in adults with dysphagia is a growing body of research. Further research is still required to address the limitations discussed above and to develop a more substantive evidence base. Tongue strengthening may be more clinically appealing if further research can highlight a relationship between tongue strengthening and delay or decrease in morbidity and mortality from aspiration pneumonia.

Conclusion

Rehabilitative interventions to dysphagia are provided over a period of time with the hope of creating permanent changes in a person's anatomy and/or physiology (Steele, 2012). There is suggestive evidence that tongue strengthening can improve swallowing function in adults with dysphagia. Further research is required in larger, homogeneous participant samples in order to determine if treatment effects can be generalized.

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