Critical Review:
Do the Mendelsohn maneuver, effortful swallow, and the Shaker exercise individually improve functional and physiological outcomes in patients experiencing oropharyngeal dysphagia post-stroke?

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Dysphagia is a common complication experienced by many patient populations including stroke, head and neck cancer, traumatic brain injury, and typical aging individuals. This critical review examines the evidence for use of the Mendelsohn maneuver (MM), effortful swallow training (EST), and the Shaker exercise (SE) with patients experiencing oropharyngeal dysphagia post-stroke. Study designs include randomized control trials and randomized block designs. Although the data collected shows a trend towards improved functional and physiological outcomes as a result of each exercise, there are limitations to generalizing the results to the entire stroke population. Overall, research is suggestive of positive effects of these three exercises, however results are inconclusive. Clinical implications and directions for future research are discussed.

Introduction

Dysphagia, or difficulty swallowing, is a common complication experienced by patients in many populations including stroke, head and neck cancer, traumatic brain injury, and typical aging individuals. According to Martino et al. (2005), 37-78% of stroke patients experience dysphagia. Two primary concerns of dysphagia are penetration and aspiration of a bolus (i.e. food or liquid; Choi et al., 2017; Vose et al., 2014). Penetration refers to the bolus entering the airway and remaining above the level of the vocal folds. Aspiration refers to the movement of the bolus below the level of the vocal folds and into the lungs where it may cause a severe respiratory infection termed aspiration pneumonia. In addition to aspiration pneumonia, possible consequences of dysphagia include malnutrition, weight loss, and dehydration which can be life-threatening, result in more frequent hospital visits, and, in turn, affect the patient's quality of life (Choi et al., 2017; Langmore et al., 1998).

Safe and efficient swallowing requires the coordination of many different oral, pharyngeal, and laryngeal muscles (Dodds et al., 1989). The lips create a seal to keep the bolus in the mouth. The tongue moves food around during chewing, collects the food into a cohesive bolus, and then propels the bolus back into the pharyngeal cavity. Once in the pharyngeal cavity, the base of the tongue and the pharyngeal walls come together to squeeze the bolus down towards the esophagus. While this is occurring, suprahyoid muscles work together to pull the hyoid bone up and forward which also moves the larynx superiorly and anteriorly (Dodds et al., 1989). This is termed hyolaryngeal elevation. This action helps to fold the epiglottis, a flap that sits at the base of the tongue, over the airway. This prevents the bolus from entering the airway. It also helps to pull open the upper esophageal sphincter (UES), allowing the bolus to flow out of the pharyngeal cavity and into the esophagus. When any of the muscles involved do not work as they are meant to, an individual is said to have dysphagia (Dodds et al., 1989).

Intervention for patients with dysphagia includes exercises that focus on strengthening oral, pharyngeal, and laryngeal muscles, with the intent to improve affected physiology (Greco et al., 2017). In addition, it has been suggested that long-term rehabilitation post-stroke can lead to therapy-induced recovery and optimize use of muscle mass and strength (Robbins et al., 2007). Three of the most commonly recommended exercises include the Mendelsohn maneuver (MM), effortful swallow training (EST), and the Shaker exercise (SE; Greco et al., 2017; McCullough et al., 2012; Park et al., 2019).

The primary action of the MM involves pausing mid-swallow when the larynx reaches its highest point of elevation. The goal of the MM is to increase the extent and duration of laryngeal elevation. This subsequently increases the width and duration of the opening of the upper esophageal sphincter (UES), allowing more time and space for the bolus to flow from the pharyngeal cavity into the esophagus (Doeltgen et al., 2017). The main objective of EST is to improve the strength and posterior motion of the tongue base by contracting the muscles as forcefully as possible. This is thought to improve bolus flow through the pharyngeal cavity, resulting in less post-swallow residue and reducing the likelihood that the bolus will enter the airway post-swallow (Hind et al., 2001; Logemann et al., 1992; Park

et al., 2019). The SE involves laying in a supine position and lifting the head up and forward enough to see the toes without raising the shoulders (Choi et al., 2017). This exercise is intended to activate and strengthen the suprahyoid muscles involved in hyolaryngeal elevation, which aid in opening the UES and, similar to the MM, results in improved bolus flow through the UES (Choi et al., 2017).

There are data to suggest that performing strengthening exercises targeting the swallowing musculature can improve physiological (e.g., hyolaryngeal elevation) and functional (e.g., pharyngeal residue) outcomes (Greco et al., 2017). However, most studies employ a battery of exercises in dysphagia intervention which makes it challenging to draw conclusions regarding the effects of any single exercise (Greco et al., 2017). Investigating the MM, EST, and the SE is of particular interest because these exercises have the potential to improve aspects of the swallow that are important for preventing penetration-aspiration and improving bolus flow through the oral and pharyngeal cavities (Choi et al., 2017; McCullough et al., 2012; Park et al., 2019). Stroke patients are of particular interest with this type of rehabilitation because they have been shown to experience higher rates of silent aspiration due to the effect strokes can have on motor and sensory nerves involved in swallowing (Robbins et al., 1999). Therefore, examination of the aforementioned exercises within the stroke population could provide support for use of this type of dysphagia intervention within clinical practice and reduce prevalence of health issues related to dysphagia such as aspiration pneumonia.

Objectives

The primary objective of this paper is to evaluate existing research on the effects of the MM, EST, and the SE on the physiology of patients experiencing dysphagia post-stroke. The secondary objective of this paper is to examine the functional outcomes of performing the MM, EST, and the SE exercises. The final objective of this paper is to provide clinical applications of the MM, EST, and the SE exercises.

Methods

Search Strategy

The computerized databases PubMed and SCOPUS were used to search for articles related to dysphagia in stroke patients using the following search terms:

> (dysphagia) AND (stroke) AND (exercise) AND (Mendelsohn maneuver) OR (effortful swallow training) OR (Shaker exercise)

Additional articles were obtained from the reference lists of articles found on the databases.

Selection Criteria

Studies that included swallowing exercises in addition to the MM, EST, and the SE were excluded if they did not separate data for the MM, EST, or the SE from the other exercises. Studies that provided compensatory or therapeutic strategies in addition to exercises were included in this review. All of the included studies excluded individuals with a neurological impairment prior to their stroke and individuals with a gastrostomy tube. The participants in each study had the ability, in varying degrees, to perform swallowing trials.

Data Collection

The literature search yielded articles relevant to the topic of interest, of which five fit the aforementioned selection criteria.

Results

Randomized Control Trial

Within evidence-based practice, randomized control trials (RCT) provide the highest level of evidence for investigating a cause-and-effect relationship because they control for extraneous variables through randomization of participants (Guyatt et al., 2000).

Choi et al. (2017) conducted a single-blind RCT to examine the effects of the SE on degree of penetration-aspiration and oral diet texture in 31 post-stroke patients with dysphagia diagnosed through a videofluoroscopic swallowing study (VFSS). The swallowing intervention occurred over four weeks (30 minutes per session; one session/ day; five days/ week). Participants in the experimental group performed the SE and were also provided with conventional dysphagia therapy (e.g. thermal tactile stimulation, compensatory maneuvers, etc.). The control group was provided with conventional dysphagia therapy only. Outcome measures included VFSS assessment completed pre- and post-intervention to evaluate incidence of penetration-aspiration. The VFSS was analyzed using a standard protocol. A standardized assessment was also used to evaluate each participant's tolerance of oral textures.

Results indicate the experimental group demonstrated improvement that was significantly greater than the control group in both the degree of penetration-aspiration and oral diet texture level.

Strengths of this study include randomization of participants into groups, blinding of participants to treatment condition, description of demographic and clinical characteristics for each group of which there

were no significant differences, and use of appropriate statistical analyses. Limitations include a small sample size, high dropout rate, short treatment duration, and the provision of conventional dysphagia therapy with both groups which may have influenced the effects of the SE.

Overall, this study provides suggestive evidence that post-stroke patients may benefit from the SE as is demonstrated through the reduction in penetration-aspiration and improvement in tolerance of oral diet textures for participants in this study.

Park et al. (2017) conducted an RCT investigating the effect of the SE on anterior-superior hyolaryngeal movement and degree of penetration-aspiration in 37 post-stroke patients with dysphagia. The swallowing intervention occurred over four weeks (once/ day; five days/ week). The experimental group was asked to lay in a supine position and raise their head to look at their toes. The control group did not perform the SE. Additionally, participants in both groups were offered conventional dysphagia therapy (e.g. thermal-tactile stimulation, orofacial musculature exercises, etc.). Outcome measures included pre- and post-intervention VFSS assessment which was analyzed using a standard protocol.

Results show that post-intervention both groups demonstrated significant improvements in the anterior-superior movement of the hyoid and larynx. The experimental group demonstrated significantly more improvement in the superior movement of the hyoid bone compared to the control group. Both groups also demonstrated significant reduction in level of penetration/ aspiration. The experimental group demonstrated significantly greater improvement in level of penetration/ aspiration when consuming liquids compared to the control group.

Strengths of this study include randomization of participants into groups, an organized parameter to examine physiological changes pre- and post-treatment, and appropriate statistical analyses. Limitations include a small sample size, short treatment duration, and the provision of conventional dysphagia therapy which may have influenced the outcome of results.

Overall, this study offers suggestive evidence that post-stroke patients who employ the SE may improve anterior-superior hyolaryngeal movement, resulting in fewer incidences of and/or decrease in severity of penetration and aspiration.

Park et al. (2019) conducted a double-blind RCT investigating the effect of EST on oropharyngeal musculature strength in 24 post-stroke patients with dysphagia diagnosed through VFSS. The swallowing intervention occurred over four weeks (three sessions/ day; five days/ week) and involved a minimum of ten swallows. The experimental group was asked to swallow their saliva with as much force as possible, while the control group was asked to swallow their saliva normally. The protocol was based on a published association position standard. Participants in both groups were also offered conventional dysphagia therapy (e.g. chin tuck, thermal tactile stimulation, etc.). Outcome measures included visual observation of swallowing, occasional palpation of the suprahyoid muscles, and VFSS assessment completed pre- and post-intervention. The VFSS was analyzed using a standard protocol. No information regarding measures for visual observation or palpation was provided.

Results of this study identified that both groups made significant improvements in both tongue strength and functional aspects of the oral and pharyngeal phases of swallowing. The experimental group demonstrated significantly greater improvements on both measures compared to the control group.

Strengths of this study include explicit and detailed descriptions of inclusion and exclusion criteria, double-blind randomization of participants into groups, blinding of the clinicians who analyzed the VFSS, and appropriate statistical analyses. Furthermore, groups were evenly matched on participant characteristics including age, gender, site of stroke, and time since occurrence of stroke. Limitations of this study include its small sample size, short treatment duration, and the provision of conventional dysphagia therapy which may have influenced the outcome of results.

Overall, this study offers suggestive evidence that EST provides stroke patients with increases in tongue strength and improvements in functional aspects of the oropharyngeal swallow.

<u>Randomized Block Trial</u>

The use of randomized block trials (RBT) involves a high level of credibility as it allocates individuals to treatment conditions in randomized fashion. It is also beneficial because it allows for all individuals within the study to benefit from the treatment being provided (Rvachew & Matthews, 2017).

McCullough et al. (2012) conducted an RBT investigating the effect of the MM on the superior-anterior movement of the hyoid and the duration of UES opening in 18 post-stroke patients with dysphagia, identified by restricted oral intake and through VFSS.

The swallowing intervention occurred over four weeks with one group receiving therapy for the first two weeks only and the second group receiving therapy for the final two weeks only. Participants were given therapy twice a day during each day of the treatment weeks, completing 30-40 successful MM swallows each treatment session. A successful MM swallow involved sustaining hyolaryngeal elevation for a minimum of 2 seconds. Surface electromyography (sEMG) was used throughout treatment to provide biofeedback. Feedback and guidance were provided following each swallow. Outcome measures included analysis of VFSS at baseline and following each week of the study.

Results of this study identified that two weeks of treatment significantly improved "duration of hyoid maximum elevation" and "duration of hyoid maximum anterior excursion." No other significant results were identified.

Strengths of this study include detailed description of methods, high intra- and interjudge reliability scores, randomization of participants into treatment groups, blinding of VFSS raters to treatment condition, and appropriate statistical analysis. Limitations of this study include a small sample size, the broad range of time post-stroke, and short treatment duration.

Overall, this study offers somewhat suggestive evidence that the MM provides stroke patients with improvements in swallowing physiology, in particular, duration of superior-anterior movement of the hyoid. No functional impacts were reported; therefore, these results are not directly indicative of changes to functional swallowing ability.

McCullough and Kim (2013) investigated the effect of the MM on the distance of superior-anterior movement of the hyoid and the average width of UES opening using data collected in the McCullough et al. (2012) study. Therefore, the participants, methods, outcome measures, strengths, and limitations for this study are the same as described previously in the McCullough et al. (2012) study.

Results of this study demonstrated that two weeks of treatment improved "hyoid maximum elevation", "hyoid maximum anterior excursion", and "mean width of UES opening" more than one week of treatment. No other significant results were identified.

Overall, this study offers somewhat suggestive evidence that the MM provides stroke patients with improved swallowing physiology, in particular, increases in the distance of superior-anterior movement of the hyoid and increases in width of UES opening. No functional impacts were reported; therefore, these results are not directly indicative of changes to functional swallowing ability.

Discussion

Individual examination of commonly used non-invasive exercises such as the MM, EST, and the SE for dysphagia management is gradually emerging. Use of the aforementioned exercises has been shown in healthy populations to augment movement of suprahyoid muscles, increase and prolong hyolaryngeal elevation, and improve tongue strength for improved airway protection, UES opening, and bolus clearance of the pharyngeal cavity (McCullough et al., 2012; Park et al., 2017; Park et al., 2019). The studies included in this review provide supporting evidence that the MM, EST, and the SE improve functional and physiological aspects of the swallow in post-stroke patients with dysphagia, similar to the effects seen in healthy populations (Choi et al., 2017; McCullough et al., 2012; McCullough et al., 2013; Park et al., 2017; Park et al., 2019).

The MM improved duration of hyoid elevation and excursion, as well as average width of UES opening following two weeks of treatment (McCullough et al., 2012; McCullough & Kim, 2013). Though functional results were not analyzed, the authors speculated that these improvements would result in less pharyngeal residue and fewer instances of penetration and/ or aspiration (McCullough et al., 2012; McCullough & Kim, 2013). EST improved both tongue strength and functional aspects of the oral and pharyngeal phases of swallowing (Park et al., 2017). Functional aspects of the oral phase that may be improved as a result of tongue strengthening include mastication, bolus formation, and movement of the tongue base. Functional aspects of the pharyngeal phase that may be improved as a result of tongue strengthening include clearing residue from the valleculae at the base of the tongue and subsequently reducing the risk of penetration and/ or aspiration (Park et al., 2017). The SE was shown to improve both functional and physiological aspects of swallowing (Choi et al., 2017; Park et al., 2017). Activation of the suprahyoid muscles that play a role in hyolaryngeal elevation resulted in improvements in the anterior-superior movement of the hyolaryngeal apparatus. This was correlated with a decrease in severity of penetration-aspiration, as well as improvements in oral diet texture level (Choi et al., 2017; Park et al., 2017).

Despite providing evidence that these exercises have positive effects on the functional and physiological aspects of swallowing, there were some common

limitations identified in the studies within this review that restrict generalization of the findings. These limitations include small sample sizes due to challenges with recruiting participants and loss of funding, high withdrawal rates, and the provision of conventional dysphagia therapy (Choi et al., 2017; McCullough et al., 2012; McCullough & Kim, 2013; Park et al., 2017; Park et al., 2019). Furthermore, no rationale was provided as to why the interventions were conducted for only two or four weeks. It is thought that lasting changes in muscle strength and function are not typically observed in less than six to eight weeks of training (Park et al., 2019). Therefore, in addition to acquiring a larger sample size, future dysphagia intervention research would benefit from addressing the dosage required to create long-term changes.

In conclusion, there are suggestive results that the MM, EST, and the SE are individually effective in improving certain physiological and functional outcomes for oropharyngeal dysphagia in post-stroke patients. The studies reviewed included randomized designs that contributed to their credibility. However, given that researchers have only recently begun to look at the effects of the MM, EST, and the SE individually, the accumulated evidence for each exercise in this critical review is limited. Additionally, caution should be used when interpreting the findings of these studies, as methodologic limitations may have implications on the generalization of results across all stroke patients with dysphagia.

Clinical Implications

Objective data reported in the studies within this critical review suggest that consistent use of the MM, EST, and the SE in a rehabilitative setting can improve coordination of oropharyngeal structures and in turn reduce the likelihood of the bolus entering the airway. It is essential to educate patients and their families on the risks and benefits of these exercises as many participants in these studies were unable to complete the study due to discomfort experienced during therapy. Based on current research, the implementation of the aforementioned swallowing interventions appears to be beneficial in clinical practice, especially when patients may only be able to handle one exercise due to various factors such as fatigue and discomfort. This review demonstrates that independent administration of the MM, EST, and the SE deserve further evaluation, as understanding the specific functional and physiological improvements made by each exercise can provide guidance to tailor post-stroke rehabilitative dysphagia therapy to the needs of each individual patient.

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