Critical Review: The Impact of Strengthening Exercises on Swallowing Function.

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This critical review examines the effects of strengthening exercises on swallowing function. Study designs include prospective cohort studies and randomized control trials. Overall, research indicates that strengthening exercises improve swallowing function; however further research is required to determine the effectiveness of strengthening exercises in dysphagia management.

Introduction

Oropharyngeal dysphagia is defined as "difficulty in swallowing or impairment in the movement of swallowed material from the pharynx to the stomach" (Lister, 2006, p. 341). Patients with dysphagia have an increased risk of mortality, malnutrition, pneumonia and a lower quality of life (QOL) (Lin et al., 2003).

Dysphagia has been reported to affect up to 22% of individuals over 55 years of age (Hind et al., 2001). This disorder is common sequelae of central nervous system diseases, neuromuscular disorders, head and neck cancer therapy and stroke (Logemann, 1998). Deteriorated swallow function is common among the elderly, and is recognized as a consequence of aging and/or as a secondary effect of progressive disease or acute events (Logemann, 1998).

Normal aging is associated with a pervasive loss of muscle mass and reduced muscle strength, known as sarcopenia (Robbins et al., 2005). Sarcopenia is a result of decreased physical activity and can be accelerated by disuse and illness (Easterling et al., 2005). Functional decline is a consequence of sarcopenia in the striated musculature of the extremities, with implications for smaller striated muscle groups such as those involved in swallowing (Robbins et al., 2005).

Exercise has been found to be beneficial in reversing the sarcopenic changes in striated muscles of the limbs in people over 60 years of age (Easterling et al., 2005). Consequently, it is believed that similar benefits should occur in other striated muscles, such as the suprahyoid muscles (Easterling et al., 2005). As a result, there has been increasing interest in the effects of exercise programs on various types of dysphagia over the past ten years (Logemann, 2006).

In dysphagia therapy, exercise programs are frequently tailored to meet the specific abnormalities of the patient (Logemann, 2006). For instance, the Shaker exercise has been used to examine the effectiveness of exercise in improving hyolaryngeal lifting and upper esophageal sphincter opening (Easterling et al., 2005). This exercise is designed to improve the duration and width of UES opening, and thus eliminate aspiration in patients with residue in the pharynx after a swallow due to poor UES opening (Easterling et al., 2005).

Furthermore, strengthening exercises for the tongue have also been investigated. Robbins et al. (2005) have studied the effects of a lingual resistance exercise program on swallowing in older individuals. The notion that tongue-strengthening exercises can significantly improve tongue function and thus swallowing function in the oral cavity and pharynx may have significant implications for dysphagia therapy.

Objectives

The primary objective of this paper is to critically evaluate the effectiveness of strengthening exercises in the prevention of long-term swallowing dysfunction. Recommendations regarding the use of strengthening exercises in dysphagia management, and suggestions for future research will also be discussed.

Methods

Search Strategy

Computerized databases, including CINAHL, ISI Web of Knowledge and Cochrane Library were searched using the following search strategy:

> ((dysphagia) OR (swallowing dysfunction)) AND ((exercise) OR (muscle training) OR (strengthening) OR (rehabilitation)).

The search was limited to articles written in English between 1985 and 2006.

Selection Criteria

Studies selected for inclusion in this critical review paper were required to investigate the impact of any type of exercise program on the physical abilities, functional abilities, and/or quality of life among healthy individuals, patients following a stroke, patients with head and neck cancer and patients with impaired swallowing function. No limits were set on the demographics of research participants or outcome measures.

Data Collection

Results of the literature search yielded the following types of articles, which were congruent with the aforementioned objectives and selection criteria: randomized controlled trial (RCT) (3), and prospective cohort study (2).

Results

Robbins et al. (2005) completed a prospective cohort intervention study, with 10 healthy subjects. Their intent was to determine the effects of an 8-week progressive lingual resistance exercise program on swallowing in older individuals, a group most at risk for dysphagia. Pre- and post-treatment measures were gathered from a videofluoroscopic study for kinematic and bolus flow assessment of swallowing at baseline and Week 8. In addition, swallowing pressures and isometric pressures were gathered at weeks 2, 4 and 6. Lastly, four subjects underwent oral magnetic resonance imaging (MRI) to measure lingual volume following the 8-week exercise regimen. Results were analyzed using repeated measure analysis of variance models. Robbins et al. (2005) reported that all subjects significantly increased their isometric pressure (week 4 $p=0.002$, week 6 $p=0.001$) and swallowing pressure (week 8 $p=0.047$). In addition, all subjects who had the MRI demonstrated an increased lingual volume of an average 5.1%.

Lazarus et al. (2003) examined the effects of two types of tongue strengthening exercises on tongue function measures in 31 healthy young subjects. In this randomized control pilot study, subjects were randomly assigned to 3 groups: a) no exercise group, b) exercise group receiving standard tongue strength exercises using a tongue depressor, and c) exercise group receiving tongue strengthening exercised using the Iowa Oral Performance Instrument (IOPI). Results were analyzed using an unpaired t-test. Second, a Fisher's exact test was used to compare means at baseline and difference in means. Third, a paired t-test was used to compare the change in means from baseline to 1 month within each group. Last, the homogeneity of regression slopes of the line relating change to baseline value was tested using one-way analysis of covariance. Results revealed a significantly greater change in maximum tongue strength in the group that received any treatment compared with the group receiving no treatment ($p=0.04$).

Shaker et al. (1997) examined the effect of a head-raising exercise on swallow-induced UES opening and hypopharyngeal intra-bolus pressure in the elderly. In this randomized control study, two groups of age-matched healthy elderly volunteers were randomly assigned to either an exercise group ($n=19$) or a sham group ($n=12$). The aim of the present study was to test the hypothesis that an isotonic/isometric neck exercise aimed at strengthening these muscles would increase the cross-sectional area of the UES deglutitive opening. This increase would be associated with a significant physiological consequence such as a decrease in hypopharyngeal intra-bolus pressure. The data collected was analyzed using two-way analysis of variance with repeated measures to account for intra-subject variability and the exercise effect. It is reported that significant improvements were noted following the real exercise regimen ($p<0.05$).

Shaker et al. (2002) aimed to evaluate the effect of exercise, directed at strengthening the suprahyoid upper esophageal sphincter (UES) opening muscles, on the deglutitive biomechanical events and functional outcome of swallowing. A group of 27 patients were examined; all had deglutitive failure due to abnormal UES opening manifested by post-swallow residue and aspiration necessitating percutaneous tube feeding. Participants were randomized to participate in either a sham ($n=7$) or real exercise ($n=11$) protocol. The effect of the exercise on the measured biomechanical parameters were tested using two-way analysis of variance (ANOVA) with repeated measures to account for intra-subject variability and the exercise effect. Results indicate that all patients who participated in the real exercise group exhibited significant improvement ($p<0.01$). Similar results were found when the 7 patients in the sham group were crossed over to the real exercise group.

Kulbersh et al. (2006) employed a prospective cohort study and cross-sectional QOL analysis to evaluate the utility of pretreatment swallowing exercises in improving post-treatment swallowing QOL in patients diagnosed with squamous cell cancer of the head and neck. Twenty-five patients were started on the UAB Dysphagia Protocol (The Mendelsohn maneuver, Shaker exercises, tongue hold, and tongue resistance) prior to the start of treatment (radiation, and chemotherapy in some cases), and 12 patients received the same protocol after treatment.

Descriptive variables were compared by the chi-square (X^2) test for categorical variables, or the *t*-test for continuous variables. Results indicate a significant increase in the magnitude of the anterior excursion of the larynx, the maximum anteroposterior diameter, and the cross-sectional area of the UES opening after the real exercise (p=0.0083).

Patients who performed pretreatment swallowing exercises showed significant improvement in their overall MDADI score (p=0.0002) compared to the control population, who underwent post treatment therapy. Furthermore, analysis of the individual domains of the MDADI demonstrated improved quality of life.

Discussion

Study Design

In three of the five studies, researchers completed a randomized control trial, which provides the highest level of evidence following systematic reviews. In the remaining two studies, researchers completed a prospective cohort study. Cohort studies are an informative and practical means of gathering data, however are less rigorous than randomized control trials.

Subject Selection and Sample Size

In all studies, participant selection and inclusion/exclusion criteria were provided and control for confounding variables. Robbins et al. (2005) selected participants from a variety of sources, which helped decrease participant selection bias, whereas Shaker et al. (1997) only studied healthy volunteers. Lastly, Lazarus et al. (2003) did not provide information regarding participant recruitment methods, thus the representativeness of their sample is in question. None of the authors provided a rationale for their limited sample size, nor did they report any power calculations.

Methodology

All outlined experimental procedures were thorough and clearly outlined, thus are reproducible.

The exercise regimen used by Robbins et al. (2005) is valid since it follows a sports medicine protocol recommended for strength training by the American College of Sports Medicine. The weekly exercise targets were dynamic and tailored to each individual's capacity, which ensured that each participant was reaching his or her full potential. Participants were provided with biofeedback during strength training to indicate successful achievement of their target pressure. In addition, a daily log documenting exercise activity was provided to all study participants. The use of biofeedback ensured that participants were performing their exercises consistently, while the logbook helped increase patient compliance.

Valid and reliable measurement tools such as the Iowa Oral Performance Instrument (IOPI), videofluoroscopic study and magnetic resonance imaging (MRI) were used to collect outcome measures. Data collection for bolus flow measure required the use of the 8-point penetration and aspiration scale, as well as subjective observation using standard criteria and definitions. Although the operational definitions used were clear, and have face and content validity, no inte-rater/intra-rater measures of reliability were completed.

The study by Lazarus et al. (2003) included two treatment groups and a control group, which helped compare and contrast the effectiveness and efficacy of each exercise regimen. Nonetheless, rationale was not provided for the design of the exercise protocol [e.g., intensity, repetitions and length]. Participants were able to practice the exercises with the examiner and were given written instructions. This helped ensure understanding of the procedures and consistency across all participants. In addition, the exercise regimen used has functional implications for patients with lingual muscle weakness, since it addresses tongue strengthening in four directions, thus maximizing a patient's range of motion. Furthermore, participants were not instructed to practice the endurance exercise, which allowed the authors to measure generalization. A logbook was provided to all treatment participants to help increase compliance, and patients received biofeedback information with the IOPI exercise to ensure consistency within and across individuals. Outcome measures were gathered using the IOPI, which is a valid and reliable measurement tool.

Although this study is well designed and executed, it contains some limitations. First, since all participants were healthy individuals, it is difficult to generalize these results to individuals with swallowing difficulties. Consequently, results cannot be applied to patients with dysphagia, who would most greatly benefit from such improvements in lingual strength. Another limitation of the study is that evaluators were not blinded to participants' group assignment.

Lastly, the authors found no significant difference between tongue strength and endurance between the two treatment groups. Consequently, they combined the results for both exercise groups for further statistical analysis. Grouping the results of both treatment groups does not fit with the original study hypothesis and does not answer the proposed research question. In addition, the authors did not provide potential explanations for the similarities found between the two treatment groups.

Kulbersh et al. (2006) utilized the UAB dysphagia protocol, which consists of four exercises used in research and clinical practice. These exercises are empirically based and are easily replicable; however the total length of the exercise program is not mentioned in the study. All patients were seen for follow-up to monitor progress and compliance with protocol, however patients were not provided with a logbook to increase compliance, or with written instructions to ensure understanding of procedure and consistency across individuals.

In this study, the M.D. Anderson Dysphagia Inventory (MDADI) was used to gather information about dysphagia-specific QOL outcome measures. It consists of questions covering four QOL domains (global, emotional, functional and physical). The MDADI is a validated and reliable self-administered survey, which is designed specifically for evaluating the impact of dysphagia on QOL in patients who have undergone treatment for their head and neck cancer. Consequently, it appears to be an appropriate tool to collect the outcome measures delineated in this study.

A potential limitation of this study is that both groups completed the MDADI survey at different times during the study. Follow-up times were 6-20 months (median 14 months) for the post-treatment group and 6-12 months (median 9 months) for the pre-treatment group, thus it is possible that the control group (post-treatment) faired worse due to the delayed effects of radiation. On the other hand, QOL studies have found that swallowing function after head/neck cancer treatment fails to improve significantly after 12 months (Kulbersh et al., 2006). Consequently, it is possible that patients QOL scores were underestimated.

In this study, patients were not randomly selected nor were they randomly assigned to the treatment groups. However, a strength is that the authors compared the MDADI adjusted means between the groups after controlling for age, race, stage, site of tumour, follow-up time, and type of treatment. This is necessary since patient characteristics and risk factors between the two treatment groups were unequally distributed. Another strength is that the QOL results for patients who received radiation and those who received chemotherapy were compared, and no statistically significant difference was found. This helped eliminate any confounding effects of the respective treatments.

Shaker et al. (1997) studied two groups of aged matched healthy volunteers. Although they extensively instructed volunteers on the exercise procedure, their actual exercise during the 6-wk period was not supervised. In addition, participants were not provided with a logbook to track their exercises and increase compliance. Consequently, day-to-day variability in compliance and effort cannot be excluded and might have influenced the outcome of this study.

In this study, valid and reliable measurement tools such as videofluoroscopic study and manometry were used to collect outcome measures. The videofluoroscopic recordings were digitized and subsequently analyzed by three separate individuals blinded to group identity (real or sham) and exercise status (before or after exercise).

This study contains several limitations, which should be considered when evaluating the evidence provided. First, the participants selected may not reflect the general population since all participants were volunteers. This may influence outcomes since volunteers are more likely to be motivated and be compliant with the experimental procedures. Lastly, although patients were randomized to the treatment groups, examiners were not blinded to the group assignment. Therefore, this may have impacted results due to experimenter bias.

The study by Shaker et al. (2002) targets a specific patient population with an exercise regimen that appears to be valid, and appropriately investigates whether the intervention achieved the desired goal. Patients with deglutitive failure were provided with written instructions to ensure consistency across individuals and a logbook was given to monitor compliance.

In this study, valid and reliable tools were used to collect outcome measures, namely videofluoroscopy. The functional assessment of swallowing (FOAMS) was also used, however the authors did not comment on its validity, reliability, sensitivity or specificity. Nonetheless, FOAMS has face validity and is supported by literature from the Wisconsin Speech Language Pathology and Audiology Association.

In addition, the investigators who performed the videofluoroscopic study and analyzed the data were blinded to group assignment, which helped decrease experimenter bias. Furthermore, to determine the inter-observer reproducibility, a second blinded individual reanalyzed the data and the authors reported good inter-rater reliability values.

Certain limitations should be considered when interpreting the results reported in this study. First, certain potentially confounding factors, such as duration of dysphagia and the etiology of abnormal UES opening, were not included in the original study and were analyzed post hoc. Second, the enrolling Speech Language Pathologist (SLP) was not blinded, thus was aware of the participants' group assignment. The same SLP performed the functional outcome assessment of swallowing (FOAMS). Several months into the study, the SLP observed that patients' ability to handle and clear secretions demonstrated significant improvement in the exercise group, but not in the sham group. Consequently, additional patients were not enrolled in the sham group. Although this practice allowed more participants to benefit from the potential benefits of the exercise group it does not follow the original study design. Furthermore, since the SLP was not blinded to the group assignment, experimenter bias may have played a role in this decision. Experimenter bias may also affect the FOAMS scores. In addition, by switching control group participants into the exercise group the study was no longer a randomized control study and its results do not provide us with the same level of evidence. Consequently, the results reported should be interpreted with caution since it is not known what results would have indicated had the study continued according to the original procedures.

Statistical Analysis

In all studies, the statistical methods employed for data analysis were appropriate and a rationale for their use was provided. Lastly, all studies utilized and reported data with a conservative p value.

Recommendations

Based on critical appraisal, these research studies provide moderately strong evidence in favour of strengthening exercises. These findings are supported by literature examining the effects of exercise on limb musculature. Nonetheless, methodological and subject selection concerns may have affected the reliability and/or validity of the research findings reviewed.

Based on these limitations, it is suggested that the following recommendations be incorporated into future research. First, various participant recruitment methods should be used to ensure that a representative sample of the population is selected. Second, individuals with swallowing difficulty should be included, in order to generalize results to patients with dysphagia. Third, potentially confounding factors, such as the duration of dysphagia and the etiology of abnormal UES opening, should be considered during patient selection.

Furthermore, study designs should include appropriate controls, randomly select and assign participants to groups, and ensure that evaluators are blinded to group assignment. In addition, it is recommended that follow-up measures be completed to determine long-term effectiveness of strengthening exercises. Lastly, criteria used to discontinue treatment should be outlined prior to the study.

Clinically, it is recommended that exercise targets be dynamic and tailored to each individual's capacity. This would ensure that each participant is reaching his or her full potential. Participants should be provided with biofeedback to indicate successful achievement of their target pressure. Lastly, a daily log documenting exercise activity should be provided to increase and monitor compliance.

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