Critical Review:

The impact of Expiratory Muscle Strength Training (EMST) on cough and swallow outcomes in clients with Parkinson's Disease

Heather Fraser
M.Cl.Sc (SLP) Candidate
University of Western Ontario: School of Communication Sciences and Disorders

This critical review examines the impact of Expiratory Muscle Strength Training (EMST) on cough and swallow outcomes in clients with Parkinson's Disease (PD). Study designs include one pre-test/post-test with control design, one single group pre-test/post-test design, and one single-subject repeated measures design. Results of the studies examined reveal encouraging outcomes in the use of EMST as a treatment option for the PD population at risk for aspiration. However more research needs to be done on the translation of EMST to functional activities involving the muscles of respiration.

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Introduction

PD is a common, slowly progressive, idiopathic neurologic disease that affects 50 people per 100,000 older than the age of 50. The pathologic changes of PD most often involve nerve cell loss in the substantia nigra and locus ceruleus, as well as decreased dopamine content in the striatum. The depletion of dopamine in the striatum is thought to be responsible for the clinical signs of PD which include resting tremor, rigidity, bradykinesia, akinesia, and postural abnormalities (Duffy, 2005).

Respiratory complications are common in PD. Aspiration pneumonia, as a result of dysphagia, is the most common cause of death associated with this disease (Troche et al., 2010). The effects of treatment on these respiratory complications are unknown to date. Improvements of tremor and rigidity have been seen in patients who were treated with Levodopa and thalamotomy, but no reductions in respiratory abnormalities were seen (De Bruin, De Bruin, Lees, & Pride, 1993).

Expiratory Muscle Strength Training (EMST) is a behavioral treatment paradigm which uses a pressure threshold device and a controlled treatment protocol to strengthen the muscles involved in expiration. This increase in strength may translate to functional improvements in cough and swallow in patients with PD. The amount of force generated by an individual is proportional to the degree of expiratory driving pressure. Increasing this pressure can improve their ability to clear the airway if needed (Sapienza, Wheeler, 2006). Increases in submental muscle force generation and in hyolaryngeal complex movement have been associated with EMST. This has been hypothesized to increase swallow safety which provides a strong rationale for the use of EMST as a treatment for dysphagia (Troche et al., 2010). Increasing expiratory driving force may have a positive functional impact on cough and swallow which are both areas of concern in patients with PD. Therefore EMST may be a viable behavioral treatment option for this population.

Objectives

The primary objective of this paper is to critically evaluate existing literature regarding the impact of EMST on cough and swallow outcomes in patients with PD. The secondary objective is to propose evidence-based practice recommendations for future research and implications of EMST for patients with PD.

Methods

Search Strategy

The research articles were found using a computerized database search, including CINAHL, PubMed, and Medline. The following key terms and search strategies were used:

> ((Expiratory Muscle Strength Training) OR (EMST) OR (Muscle Strength Training)) AND ((Parkinson's Disease) OR (PD)) AND ((Swallowing) OR (Dysphagia) OR (Cough) OR (Maximum Expiratory Pressure))

Selection Criteria

Research studies selected for inclusion in this critical review paper were required to be published in English and to investigate the impact of EMST on cough and swallow outcomes in patients with PD. No limits were set on the dates of the articles published or the demographics of the research participants.

Data Collection
Results of the literature search yielded the following three quantitative, prospective studies that met the aforementioned selection criteria: pre-test/post-test with control design (1), single group pre-test/post-test (1), and single-subject repeated measures design (1).

Results

Troche et al. (2010) based their study on the mechanistic underpinning that EMST could improve swallow safety by increasing the submental musculature. This increase in force activation would improve elevation and excursion of the hyolaryngeal complex during the swallow. Troche and colleagues (2010) used a prospective, randomized, blinded, placebo-controlled clinical trial to test the effects of EMST on swallow safety in patients with PD. Sixty participants with PD completed EMST for 4 weeks, 5 days a week, for 20 minutes per day, using a calibrated or sham (placebo), handheld device. The treatment approach was used to measure swallow safety (penetration-aspiration [PA] scale scores), swallow timing, and hyoid movement. Judgments of these measures were made from videofluoroscopic images. All participants were randomly assigned to the active treatment group (n=30) or sham treatment group (n=30). The sham device was identical to the EMST device except the pressure release valve was made to be nonfunctional by removing the spring. Given that these devices both looked the same, both clinician and participant were blinded to treatment randomization. All participants completed a baseline swallowing assessment, followed by 4 weeks of active or sham treatment. Upon completion of either treatment arm, the participants returned for a post-treatment assessment.

There was no difference in the baseline characteristics of the EMST group compared to the sham treatment group (p = 0.881). An interaction between time and group was identified with the use of repeated measures-analysis of covariance test (F = 10.87, p = 0.001). Eleven patients (33%) had improved PA scores following EMST as compared to 5 (14%) in the sham group. Three patients (9%) had deteriorated PA scores following EMST as compared to 16 (46%) in the sham group. There was no statistical change in duration of hyoid elevation over time in the EMST group but it decreased significantly in the sham group post-treatment. There was a time by treatment group interaction for hyoid elevation duration (F = 5.388, p = 0.029). Time by treatment group interactions were significant for hyoid displacement at several swallow specific events: onset of bolus transit, upper esophageal sphincter (UES) opening, UES at its widest opening, UES closure, laryngeal closure, maximum laryngeal closure, and laryngeal opening (p-values were not given for these time by treatment group interactions). Displacements increased (not always significantly) for all events in the EMST group, but decreased (not always significantly) for all events in the sham group. There was improvement in swallowing-related quality of life (QOL) secondary to treatment and independent of the treatment group (F = 3.007, p = 0.007).

Troche and colleagues (2010) presented Level II statistical evidence and showed an important clinically-relevant finding which was the significant reduction of PA scores in the EMST treatment group. There are some limitations of this study, such as: the participants had only mild to moderately impaired swallowing, and they did not control for disease severity or dysphagia specific domains in order to better examine the patient profiles for which EMST is most effective. This study does, however, have many strengths which include: the authors used a large sample size, there was good inter-rater reliability, and all assessments were randomized and completed by blind raters. The researchers provided a thorough description of the research design and used appropriate statistical analysis and measurement techniques, therefore providing compelling evidence that EMST may be a viable behavioral treatment option for dysphagia in patients with PD.

Upper airway obstruction may be due to an underlying weakness of the expiratory muscles. Expiratory muscle strength, typically determined from the generation of maximum expiratory pressure (MEP), is often reduced in patients with PD. It is also positively correlated with increasing clinical severity of the patients. Saleem, Sapienza, and Okun (2005) used a single subject, repeated measures design to examine the effects of EMST on the generation of MEP. They hypothesized that EMST would cause an adaptation in the expiratory muscles compared to the well-documented adaptations that occur in limb muscles following strength training.

The participant was diagnosed with tremor-predominant idiopathic Parkinson's disease (IPD) with a disease duration of 5 years. The participant was exposed to 2 sessions of baseline measurements, separated by 1 week, followed by the 4 week EMST program. She then underwent a follow-up measurement session in the seventh week. The patient was motivated to continue using the device due to self-perceived gains. She was followed for an additional 16 weeks, bringing the total training duration to 20 weeks. Follow-up measures were collected after the treatment ended and once more following a 4 week detraining period.

The results of the baseline, training, and detraining were plotted and visually inspected (no statistical analysis was completed). MEP increased by 55% from baseline as measured after the 4 week endpoint with a final improvement of 158% from baseline. After a detraining period of 4 weeks there was a 16% reduction in MEP. The MEP value after detraining was 104% above that obtained before exposure to EMST.

The strengths of this study include: good training on the use of the device (e.g., given a expiratory pressure threshold trainer, verbal instructions on device handling and appropriate labial closure, mid-week phone calls to ensure compliance with guidelines, etc). The limitations include: small sample size limiting it to one stage and severity of the disease, and the client was extremely motivated. This study presents Level I statistical evidence. Due to limitations of the single case study, there is only suggestive evidence that EMST increases the strength of the expiration muscles and in turn the generation of increased MEP. Whether the increase in MEP can translate to functional activities of the respiratory muscles such as cough and swallow needs further study.

There is a high occurrence of morbidity and mortality due to aspiration in PD, therefore, treatments focusing on airway protection while improving cough effectiveness are ideal. Pitts, Bolser, Rosenbek, Troche, Okun, and Sapienza (2009) used a single group pre/post-test design to test whether EMST improved cough and swallow function in patients with PD. Ten male participants with midstage PD who had videofluorographic evidence of penetration (P) or with evidence of aspiration (A) of material during swallow completed a 4 week EMST program. They measured parameters from an airflow waveform produced during voluntary cough pre- and post-EMST. These parameters included: inspiration phase duration, compression phase duration (CPD), expiratory phase peak flow (EPPF), expiratory phase rise time (EPRT), and cough volume acceleration (VA = EPPF/EPRT). The swallow outcome measure was the degree of P/A during the swallow task. It was hypothesized that the voluntary cough airflow pattern in those with PD with known P/A would improve significantly following EMST, and that there would be a significant decrease in the P/A score.

The participants completed one baseline session and then a follow-up session 1 week following completion of the training. During this 4 week training program the participants used the device at home 5 days a week with 5 sets of 5 breaths per day. Measurements were assessed using intraclass correlation coefficients. Results showed that P/A scores before and after training significantly decreased ($Z = 2.388$; $p = 0.01$). There was a significant increase in P_{Emax} (maximum air pressure generated as in indirect measure of expiratory muscle strength) due to training. The mean P_{Emax} before training was 108.2 ± 23.2 and the P_{Emax} following training was 135.9 ± 37.5. When looking at the parameters of voluntary cough there was a significant reduction in the CPD ($Z = 2.803$; $p = 0.005$) and EPRT ($Z = 2.492$; $p = 0.01$). Due to the decrease in EPRT, there was a significant increase in cough VA ($Z = 2.497$; $p = 0.001$). All other parameters showed no significant changes following EMST training.

Pitts et al. (2009) concluded that the overall effectiveness of the patient's voluntary cough increased as indicated by the increase in cough VA. This relates to the ability of the cough to create shearing forces and remove unwanted material from the airway. These researchers also concluded that there was clear improvement in the patients' swallow, as revealed by the P/A scores following EMST training. The strengths of this study include: good intrameasurer reliability, the measures of the videofluorographic images were done by a qualified Speech-Language Pathologist who was blinded to experimental condition, and clear verbal and written instructions of the tasks provided to the participants. The limitations of this study include: small sample size, and the participants were all of the same gender. This study presents Level III statistical evidence. Due to the limitations, there is only suggestive evidence that EMST training is a viable treatment option to improve cough and swallow function in patients with PD.

Discussion

Based on appraisal of the literature, there appears to be suggestive evidence that EMST can improve cough and swallow function in patients with PD. Caution must be used when interpreting and generalizing these results due to the limitations of the reviewed articles. Troche and colleagues (2010) had a sound design and a large sample size but they did not control for the stage of PD. This information would have important clinical applications as to whether EMST is suited for patients in all stages of PD. It can also help determine whether it can be used as a preventative tool in the early stages. These researchers were also the only ones to measure swallowing related QOL. Knowing whether an intervention tool improves QOL is of high priority clinically. Pitts and colleagues (2009) were the only researchers who looked at the degree of P/A in the participants and measured voluntary cough parameters. The other 2 studies predicted that an increase in MEP would, in turn, improve cough and swallow function, but did not provide evidence to support this generalization.

Clinical Implications

Due to the level of evidence provided by the reviewed articles, caution should be used when applying these findings clinically until further research is completed. The rationale for the use of EMST for patients with PD is based on the sound evidence that supports the use of strength training in the limb muscles. EMST may be more appealing clinically if future research can determine a relationship between EMST and a delay in morbidity and mortality from aspiration pneumonia in PD.

Recommendations

Based on the limitations of the current literature it is recommended that further research be conducted to examine the effects of EMST on cough and swallow function in patients with PD. In order to provide more compelling evidence, research should include the following:

- Collection of data to assess whether EMST treatment effects generalize to reductions in aspiration pneumonia in patients with PD.
- Increased sample size and, and control for disease severity (e.g., early vs. late-stage PD). This may provide information on the role of EMST as a preventative treatment option.
- Longitudinal studies to assess the durability of EMST and whether retraining or maintenance therapy is warranted.
- Questionnaires to examine the effects of EMST on quality of life.

Conclusion

There is suggestive evidence that EMST can improve cough and swallow function in patients with PD. Further research is needed to determine whether EMST treatment effects generalize to reductions in aspiration pneumonia and improve QOL. Caution should be used when applying these findings clinically until further research is completed.

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