Critical Review:
Does the addition of sEMG biofeedback to behavioural dysphagia intervention yield better swallowing-related outcomes in adults with dysphagia?

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This critical review examined the effectiveness of sEMG as a biofeedback tool in the delivery of behavioural dysphagia therapy in various clinical populations. A literature search yielded a mix of crossover studies, single subject studies, single group studies, and a case series. Overall, the evidence is unclear for the implementation of sEMG biofeedback in routine dysphagia therapy. Study limitations, clinical implications, and suggestions for future research are discussed.

Introduction

Oropharyngeal dysphagia is described as a disturbance in the preparation or transport of a bolus (food or liquid ingested by mouth) from the oral cavity to the pharyngeal tract. Dysphagia can occur as a symptom of neurogenic, structural, or mechanical impairment. It is commonly associated with stroke, head and neck cancer, Parkinson's disease, and acquired brain injury (Ekberg, 2012). Behavioural intervention for dysphagia includes client training of exercise protocols and voluntary maneuvers in order to change the pattern of swallowing (Logemann, 1983). This intervention approach requires the learning of novel, specific, and sometimes challenging skills and movements (Crary, Carnaby, Groher, & Helseth, 2004).

The use of biofeedback has been reported to improve task-specific skill training by increasing cognitive control over biomechanical performance (Athukorala, Jones, Sella, & Huckabee, 2014). Surface electromyography (sEMG) is an inexpensive, non-invasive, and accessible biofeedback tool that can be used in dysphagia therapy to display muscle activity during a swallow to both the patient and therapist (O'Kane, Groher, Silva, & Osborn, 2010). Currently, there are commercially available sEMG biofeedback treatment programs geared specifically towards dysphagia therapy (Accelerated Care Plus Corporation, 2018).

The majority of research studies that have implemented sEMG biofeedback in dysphagia therapy have used this approach to train two specific maneuvers: the Mendelsohn maneuver and the effortful swallow (Bryant, 1991; Huckabee & Cannito, 1999; Crary et al., 2004; Bogaardt, Grolman, & Fokkens, 2009; McCullough et al., 2012; Steele et al., 2012; McCullough & Kim, 2013). The Mendelsohn maneuver is used to improve bolus flow by prolonging elevation of the hyolaryngeal complex and opening of the upper esophageal sphincter (Mendelsohn & McConell, 1987). The effortful swallow technique involves swallowing with greater effort of muscle contraction to facilitate bolus clearance from the pharyngeal tract (Kahrilas, Logemann, Lin, & Ergun, 1992). sEMG biofeedback can potentially serve as a useful adjunct to the training of these strategies by providing visual and/or auditory targets for muscle contraction amplitude and duration (Steele et al., 2012).

Due to the availability of commercial biofeedback tools geared towards dysphagia therapy, it is important to evaluate the evidence supporting the use of this technique as an adjunct to behavioural dysphagia therapy. Additionally, it is important for speech-language pathologists to ensure that the training of specific skills, through the use of biofeedback, generalizes to broader improvements in physiologic, functional, and/or socioemotional outcomes for individuals with dysphagia.

Objectives

The purpose of this critical review was to compile evidence on the effectiveness of sEMG as a biofeedback tool in the delivery of behavioural dysphagia therapy in various clinical populations.

Methods

Search Strategy

Online databases (PubMed, Google Scholar, CINAHL, Western Libraries, and ASHA Publications) were searched using the following terms: (sEMG biofeedback) or (EMG biofeedback) or (electromyographic biofeedback) AND (swallowing) or (dysphagia) AND (adults).

Selection Criteria

Studies selected for inclusion were required to implement sEMG biofeedback in behavioural dysphagia treatment as well as report outcomes on the effectiveness of this combined therapy approach. Studies were limited to

adults with confirmed dysphagia. Only studies available in English were included.

Data Collection

The results of the literature search yielded nine studies that met the selection criteria: two crossover studies, one single subject study, five single group pre- and post-intervention studies, and one case series study.

Results

Crossover Studies

A crossover study design is a repeated measurements design where each participant receives different treatments during different time points, i.e., a patient crosses over from one treatment to another (or to a no treatment condition) during the course of the trial. Thus, each patient serves as his/her own matched control.

McCullough et al. (2012) conducted a crossover study to examine the effectiveness of the Mendelsohn maneuver in the treatment of 18 patients with post-stroke dysphagia. Patients were randomly assigned to one of two treatment schedules: AABB and BBAA where A is one week of treatment and B is one week of no treatment. Measurements were obtained at baseline and following each week of treatment/no treatment, as well as at one month and one year following treatment conclusion.

Patient inclusion/exclusion criteria and treatment methodology were well-described. An appropriate tool was used to confirm the presence of dysphagia prior to intervention. This intensive treatment (45-minute sessions, 2x/day) included training of the Mendelsohn maneuver with the use of sEMG biofeedback from submental muscles. Every patient successfully completed at least 30 Mendelsohn swallows during each session with the use of sEMG biofeedback. Outcome measures included changes in the duration of components of the swallow (e.g., duration of hyolaryngeal elevation and hyolaryngeal anterior excursion) and clinician-rated dysphagia severity measures. Good reliability data were reported.

Appropriate statistical analysis revealed that some swallow duration measures improved following treatment, but these effects did not last during the 'no treatment' weeks. Other outcome measures showed minimal change.

This study provides suggestive evidence of the use of sEMG in behavioural dysphagia therapy. The purpose of biofeedback in this study was to train the expectations of the targeted maneuver and this was successfully achieved using sEMG, despite limited change in other outcome measures.

McCullough & Kim (2013) did an additional study using the same dataset and methods described in the previous study by McCullough et al. (2012). However, one patient was excluded due to loss of data. The study included analysis of three additional outcomes related to the size of movement of structures involved in swallowing (i.e., hyoid bone and upper esophageal sphincter). Good reliability data were reported.

Appropriate statistical analysis revealed non-significant improvements in all three outcomes, some of which were maintained at one-month follow-up.

This study provides suggestive evidence of the effectiveness of sEMG biofeedback in the training of the Mendelsohn maneuver which is frequently implemented in behavioural dysphagia therapy.

Single Subject Studies

Single subject studies examine the effects of an intervention within a single participant, who acts as his/her own control, through repeated measures. These studies give researchers an indication of how members of a population respond to specific treatments but have poor external validity.

Bryant (1991) conducted a single subject study to evaluate the effectiveness of sEMG biofeedback in the treatment of a patient with dysphagia following recurrent oral and lymphatic cancer. Baseline swallowing function was assessed using a gold-standard protocol and revealed severe-to-profound dysphagia, and the patient received nutrition through a feeding tube. An intensive, 10-week treatment protocol, including a home program, was initiated. sEMG biofeedback was used to train the Mendelsohn maneuver and effortful swallow. sEMG electrodes were placed on the submental muscles and biofeedback was presented in auditory and visual modalities. Additional compensatory strategies were also used to target specific dysphagia symptoms. Treatment methodology was clearly described.

No statistical analysis was conducted; however, physiologic, functional, and subjective patient outcomes were reported at multiple timepoints over the course of treatment. A gold-standard protocol was used to evaluate post-treatment swallowing function. By the end of the 10-week treatment protocol, the patient demonstrated large improvements in swallowing function and resumed total oral intake, tolerating most food textures. The patient reported that the use of biofeedback aided her understanding of therapeutic expectations.

This study provides suggestive evidence that the use of biofeedback is an effective adjunct to behavioural dysphagia therapy. However, this treatment protocol was

time- and resource-intensive, and hence may not be feasible for all patients.

Single Group (Pre- and Post-Intervention) Studies

This study design includes a single group of participants who are measured on a variable of interest, exposed to an intervention, and then measured again to determine change between pre- and post-intervention time points. However, due to the lack of a control group, it is difficult to attribute changes to the intervention as it is possible that other variables contributed to the observed outcome.

Crary (1995) examined the effectiveness of a combined behavioural and sEMG biofeedback treatment protocol in six patients with chronic dysphagia secondary to brainstem stroke. Patient inclusion criteria and study methodology were clearly described. Measurements were completed at baseline, immediately post-treatment, and at 18-24 months post-treatment. A gold-standard protocol was used to confirm the presence of dysphagia prior to treatment. All patients were feeding tube dependent at baseline.

The treatment protocol involved the training of sustained oral and pharyngeal postures during swallowing with the use of sEMG biofeedback from the region between the hyoid bone and thyroid cartilage. The aim of this treatment was to improve the coordination and strength of each patient's swallow. It also included a daily home program with the use of a portable sEMG biofeedback device. The number of sessions and length of treatment block varied across patients depending on rate of improvement in swallowing function. Outcome measures included imaging findings related to swallow physiology, clinician-rated assessment results, and long-term patient questionnaires.

No statistical analysis was conducted which is appropriate considering the small sample size; however, mean and standard deviation data were reported. Five patients resumed oral intake post-treatment. The remaining patient demonstrated limited improvement in swallowing function. At long-term follow-up (18-24 months), all patients reported subjective improvements in swallowing function.

This study provides suggestive evidence of the effectiveness of sEMG in behavioural dysphagia therapy.

Huckabee & Cannito (1999) conducted a single group pre- and post-intervention study examining the outcomes of a combined sEMG and behavioural treatment protocol in 10 patients with dysphagia secondary to brainstem injury. Patient charts, swallow physiology imaging data, and patient questionnaires were reviewed retrospectively following treatment conclusion to determine changes in swallowing outcomes. Measurements were collected at baseline and at one week and one-four years post-treatment.

Patient inclusion/exclusion criteria were well-described. The presence of dysphagia was confirmed using a gold-standard protocol and baseline diet levels were determined (ranging from feeding tube only to oral intake only). At baseline, all patients had moderate-to-profound dysphagia and were dependent on a feeding tube for nutrition. 70% of patients received prior dysphagia treatment without success; however, details regarding the prior interventions were not specified. This intensive treatment (2 hours/day; 5 days) included training of the Mendelsohn maneuver, the effortful swallow, and other additional exercises, with the provision of sEMG biofeedback from submental muscles. All patients reported that they continued these exercises formally or at home following completion of this program. Treatment methodology was well-described. Outcome measures included dysphagia severity determined through imaging as well as diet level scores.

Appropriate statistical analysis revealed that the median severity of dysphagia was significantly lower immediately post-treatment. Nine patients demonstrated improved diet level scores at one-week post-treatment. However, at long-term follow-up (one-four years post-treatment), six patients continued to progress while the rest plateaued or declined in their diet level scores.

This study provides suggestive evidence of the effectiveness of sEMG as an adjunct to behavioural dysphagia therapy.

Crary et al. (2004) investigated outcomes of an intensive dysphagia therapy program, with sEMG biofeedback, in 45 adults with pharyngeal dysphagia secondary to stroke (n=25) and head and neck cancer (HNC; n=20). This single group study involved retrospective review of therapy outcomes following treatment conclusion. Participant inclusion/exclusion criteria and treatment methodology were broadly described. Measurements were conducted at baseline and immediately post-treatment.

The presence of dysphagia at baseline was identified using a gold-standard protocol. The treatment protocol (50-minute sessions, 1x/day) included several behavioural compensatory and management strategies (including the Mendelsohn maneuver) as well as a home program. sEMG biofeedback was used to provide duration and amplitude targets from muscles between the hyoid bone and thyroid cartilage. Patients were discharged from treatment when both the patient and clinician agreed that sufficient progress had been made

or that further progress was unlikely. Outcome measures included change in diet level scores, length of treatment, and estimated cost of treatment.

Appropriate statistical analysis revealed that both groups showed non-significant improvement in diet level scores. A significant proportion of patients with stroke, but not HNC, resumed total oral intake. The treatment was more cost-effective for patients with stroke since they gained greater functional outcomes despite requiring more therapy sessions than the HNC group.

This study provides equivocal evidence for the use of sEMG in dysphagia therapy. While the authors report that it was an effective adjunct to behavioural treatment, the results of this study did not provide sufficient evidence to support this conclusion. Also, the effectiveness of sEMG was not well-documented.

Bogaardt et al. (2009) examined the use of sEMG biofeedback in the treatment of 11 adults with chronic post-stroke dysphagia. Patient charts were reviewed retrospectively to evaluate outcomes following treatment conclusion. Measurements were obtained pre- and post-treatment. Patient inclusion/exclusion criteria were not clearly specified. An appropriate tool was used to confirm presence of dysphagia prior to intervention.

Treatment included intensive training (3-4x/day; 29-168 days) of the modified Mendelsohn maneuver with sEMG biofeedback from submental muscles. Home practice without the use of sEMG biofeedback was completed by all patients, 2-3 times per day. Some participants also completed additional exercises, but the purpose of allocation of additional exercises was not clearly described. Number of sessions and length of treatment block also varied across patients, depending on rate of improvement and length of time required to achieve a satisfactory level of oral intake. Outcome measures included diet change, tube feeding dependence, and direct imaging of swallow physiology.

Appropriate statistical analysis revealed significant improvements in diet scores post-intervention. Six of eight clients who were previously feeding tube dependent resumed oral intake by the time treatment was concluded.

This study provides suggestive evidence of the effectiveness of sEMG as a biofeedback tool in the delivery of behavioural dysphagia therapy.

Athukorala et al. (2014) conducted a single group pre- and post-intervention study to determine the effects of a skill training treatment protocol in 10 patients with dysphagia secondary to Parkinson's disease. The treatment protocol included providing patients with sEMG biofeedback from submental muscles. Measurements were obtained at two baseline sessions (two weeks and one week before the start of treatment), at the end of treatment, and at two weeks post-treatment to assess skill retention.

Patient inclusion/exclusion criteria and treatment methodology were well-described. Appropriate tools were used to confirm the presence of dysphagia prior to intervention. The intensive therapy protocol was implemented over 10 days and aimed to improve conscious control over the duration and effort of dry/saliva swallows. Outcome measures included patient-reported quality of life, sEMG measures of swallow timing, and appropriate tools to measure swallow duration for liquids and solids.

Appropriate statistical analysis revealed significant improvement in dry and liquid swallow duration measures. Carry-over effects were observed from dry to water swallows. However, no improvements were observed in swallow efficiency and duration for solids. Patient-reported quality of life also improved following treatment. These improvements were maintained at two-weeks follow-up.

This study provides suggestive evidence of the effectiveness of sEMG biofeedback in the delivery of behavioural dysphagia therapy.

Case Series

A case series is a collection of case reports involving patients who are provided with a similar treatment. These reports tend to contain detailed information on patient demographics, diagnosis, treatment, and treatment outcomes, but have limited generalizability.

Steele et al. (2012) conducted a case series to determine the efficacy of sEMG biofeedback in the treatment of eight patients with neurogenic dysphagia. Patient inclusion/exclusion criteria were broadly described. A gold-standard protocol and appropriate clinician-rated tools were used to assess dysphagia severity. Measurements were obtained at baseline and post-treatment.

Treatment (2x/week; 20-24 sessions) involved training of the Mendelsohn maneuver and effortful swallow using sEMG biofeedback from submental muscles. Treatment methodology was clearly described. Outcome measures included imaging studies of swallow physiology, appropriate clinician-rated tools, as well as the association between these measures and sEMG findings (i.e., whether improvement in one measure predicted the other).

No statistical analysis was conducted; however, individual patient data were reported. Post-treatment instrumental and clinician-rated outcomes were variable among patients. Improvements in sEMG data did not translate to improved swallowing function in all patients.

This study provides equivocal evidence of the effectiveness of sEMG biofeedback in the delivery of behavioural dysphagia therapy due to its small sample size and large variability in outcome findings.

Discussion

The studies reviewed in this paper suggest that the use of sEMG biofeedback can yield positive outcomes when combined with behavioural dysphagia therapy. The use of sEMG biofeedback can play an important role in increasing conscious awareness of the swallow, clarifying and training therapeutic expectations, providing effort/timing targets and immediate feedback, and maintaining records of treatment progress. It may also potentially benefit clients who have difficulty understanding or retaining instructions related to trained maneuvers.

The literature on behavioural dysphagia therapy in neurogenic populations is currently mixed. A randomized controlled trial investigating the use of video-assisted biofeedback in 42 patients with Parkinson's disease revealed no significant differences in outcomes between the group that received behavioural intervention alone versus the group that received additional biofeedback. However, patients in the biofeedback group reported better self-perceived outcomes (Manor, Mootanah, Freud, Giladi, & Cohen, 2013). A systematic review on behavioural dysphagia therapy in patients with Parkinson's disease (without biofeedback) concluded that the evidence to support the effects of these treatments is currently insufficient (Park et al., 2019).

Treatment protocols described in the reviewed studies were intensive and five included an active home program (Bryant, 1991; Crary, 1995; Huckabee & Cannito, 1999; Crary et al., 2004; Bogaardt et al., 2009). However, dysphagia etiology and severity, outcome measures, length of treatment blocks, hours of direct treatment, and the addition of other therapy strategies were inconsistent within and across studies. These differences made it difficult to draw definitive judgments on the implementation of sEMG biofeedback in behavioural dysphagia treatment. Therefore, while biofeedback may have a positive role in dysphagia treatment, current research is not sufficient to design a standard protocol combining sEMG and behavioural intervention.

Additionally, due to small sample sizes and the lack of control groups in all the reviewed studies, it is unclear whether sEMG biofeedback should be recommended for routine use in the treatment of dysphagia. Also, only two studies reported long-term outcomes following conclusion of treatment (Crary, 1995; Huckabee & Cannito, 1999). Therefore, it is difficult to judge the long-term effectiveness of a combined sEMG biofeedback and behavioural treatment approach on swallowing function and quality of life.

Conclusion

The studies reviewed generally provide suggestive evidence of the effectiveness of sEMG biofeedback in the delivery of behavioural dysphagia therapy. Limitations of the currently available research include variability in clinical populations and treatment protocols, small sample sizes, and the lack of control groups for comparison to a 'no feedback' condition. For sEMG biofeedback to be recommended as an adjunct to behavioural dysphagia treatment, further evidence from well-designed, large-scale, randomized controlled trials is needed.

Clinical Implications

Currently, there is a lack of sufficient evidence to support the effectiveness of sEMG biofeedback in behavioural dysphagia therapy. However, the studies included in this critical review provide overall positive results for the implementation of this biofeedback tool. sEMG biofeedback can be used to provide external therapy targets, train specific maneuvers, and document patient progress. It also provides real-time information on muscle activity, thus serving to improve patient motivation and performance (Albuquerque, Pernambuco, da Silva, Chateaubriand, & da Silva, 2019). Furthermore, no negative impacts of this biofeedback tool were revealed in the literature. Given this information, clinicians may consider the implementation of sEMG biofeedback on a case-by-case basis if it provides benefit to the patient to have external visual and/or auditory targets during dysphagia therapy.

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