



Effectiveness of Electrical Stimulation among patients with Voice Disorders - Review Article

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ABSTRACT:

Objective: Electrical stimulation paired with voice therapy has shown effective results in patients with voice difficulties, therefore, this paper aims to find the link between the efficacy of electrical stimulation among individuals with voice disorders based on the findings of present literature.

Purpose: The purpose of this study is to find answers to the following questions

- 1) Can electrical stimulation improve vocal fold adduction?
- 2) Can electrical stimulation improve voice quality and loudness?
- 3) Is electrical stimulation in isolation effective for patients with voice disorders?
- 4) Does voice therapy adjunctive with electrical stimulation effective for individuals with voice problems?

Method: A thorough literature search was conducted with a focus on two keywords; "voice disorders" and "electrical stimulation". 19 different articles were recruited from Pub med and google scholar from the year 2008 till date. The findings were analyzed to form a conclusion based on facts.

Conclusion: The application of surface electrical stimulation combined with traditional voice exercises improves vocal intensity, pitch and enhances voice quality and it is an effective treatment modality for dysphonia, presbyphonia, vocal fold paralysis and paresis.

Keywords: Electrical stimulation, voice disorders, vocal fold adduction, voice therapy

I. INTRODUCTION

Speech-language pathologists are expert professionals in managing voice disorders with different behavioural readjustments related to the concept of voice therapy. The two major targets that voice therapy aims at; vocal hygiene advice and correction of incorrect vocal techniques that may lead to vocal cord injury (Kotby & Fex, 1998).

In various researches, it is reported that Neuromuscular Electrical stimulation (NMES) and Transcutaneous electrical nerve stimulation (TENS) not only benefit the patient with swallowing disorder but also have a positive outcome in voice therapy (Santos, Gama, Silvério, & Oliveira, 2015). These are the two known methods for providing surface electrical stimulation. The term NMES is described as indirect muscle stimulation, where a muscle contraction is achieved in response to the stimulation of the innervating nerve. (Gondin, Duclay, & Martin, 2006) TENS is a non-invasive method to reduce pain as it promotes muscle relaxation, improves vascularization at the site of application and also reduces muscle fatigue and overactivity (Guirro et al., 2008).

With the passing years' speech-language therapists have used other treatment modalities with conventional therapeutic strategies to decrease the treatment duration, therefore, the use of electrical stimulation adjunct with voice therapy in evidence-based practice is still new, according to the literature electrical stimulation has been used with different vocal pathologies – dysphonia, presbyphonia, vocal fold paralysis and paresis and vocal nodules as a combined treatment modality with traditional voice exercises. Some researchers have reported positive outcomes but

still, this topic is under debate as limited research is conducted in the area.

The concept of surface electrical stimulation in combination with voice exercises for the management of recurrent paresis as “neuromuscular electrophonographic stimulation – NMEPS” was initially proposed by Pahn (Pahn, 2000). The main objective of electrical stimulation therapy for protection and regeneration is that only damaged muscles are stimulated in such a way – that electrical pulse is given to damaged muscle forcing it to contract (Ras, Imam, El-Banna, & Hamouda, 2016). The purpose of combined treatment modalities; voice therapy with electrical stimulation is to regain the lost nerve function “regeneration efficiency”. It also protects the denervated muscle from deterioration. (Ptok & Strack, 2008). In recent studies, the use of NMES with normal healthy adults has caused a remarkable change in the vocal fold movement and acoustic characteristics when evaluated. Also combining NMES with voice therapy have shown positive results in patients with vocal pathologies. (LaGorio, Carnaby-Mann, & Crary, 2010) TENS, on the other hand, is an effective method for reducing muscle tension according to the physiotherapy literature, in previous studies TENS was used by speech therapists for treatment of muscle tension dysphonia (Stepp, Hillman, & Heaton, 2010) however the worldwide, evidence-based use of electrical stimulation in the speech and voice disorders is limited.

This aim of this article is to review the previous literature and to find answers for the following queries; Can surface electrical stimulation improve vocal fold adduction, increase loudness, improve the overall acoustics and laryngeal structure and the use of electrical stimulation either NMES or TENS adjunctive with voice therapy effective for overall voice disorders or difficulties.

II. The effect of electrical stimulation on vocal fold adduction

It has been reported in different papers that VitalStim therapy plays a vital role in the opening and closing of false and true vocal folds to prevent aspiration. Humbert and colleagues conducted a research in which they tried 10 different electrode placements on the submental muscle and neck area of 27 healthy adults to gauge the activity of true vocal fold, they used Fiberoptic nasolaryngoscopic during the electrical stimulation – results of this study revealed that vocal folds angles changed to a small extent during two-electrode placements, therefore, it was concluded that surface electrical stimulation on the submental and neck region do not have an immediate effect on vocal fold adduction (Humbert, Poletto, Saxon, Kearney, & Ludlow, 2008).

To assess the effect of transcutaneous electrical stimulation on vocal fold adduction a group of clinical investigators in Europe introduced transcutaneous electrical stimulation (TES) protocol, 32 normal individuals participated in the study, they were given high-frequency electrical current for short duration via a surface electrode placed above the entrance of internal superior laryngeal nerve to the larynx. After the quantitative analysis and judgement of vocal fold movements by experienced speech-language pathologists, it was concluded that there is significant adduction in vocal folds due to TES protocol and further research is required in neurologic voice disorders to use TES as a complementary treatment modality (Seifpanahi, Izadi, Jamshidi, & Shirmohammadi, 2017).

III. Electrical Stimulation improve voice quality and loudness

The contraction of laryngeal muscles induces a change in the vocal pitch therefore to determine the contraction speed of laryngeal muscles a study was conducted by Kempster and colleagues, they inserted wired electrodes in the cricothyroid and arytenoid muscles of normal subjects - single low voltage shocks during phonation to single muscle was given at one time, the frequency of shocks was varied from 1 to 90/s. The findings revealed that both muscles cause elevation of vocal pitch (Kempster, Larson, & Kistler, 1988). Traditional voice therapy techniques and exercises have been used in the past with individuals with voice disorders and only a few types of research have documented the effects of electrical stimulation on the acoustic, perceptual and aerodynamics features of voice. A group of researchers examined the long-term effects on electrical stimulation on the posterior cricoarytenoid (PCA) muscle to observe the change in vocal parameters. Two patients were selected for this trial - “Medtronic Itrel II laryngeal pacemaker” was implanted through surgery. Voice evaluation was performed pre and postoperatively with pacemaker off. Findings revealed that there is no significant effect of PCA stimulation on voice. (Billante, Courey, Zeale, & Netteville, 2002) to further confirm the hypothesis that transcutaneous electrical stimulation (TES) changes the voice quality – a study was conducted to examine the acoustic change in the voice of healthy individuals

following TES, thirty-one normal speakers with the normal voice were selected, two pair of surface electrodes were placed on the anterior neck they received TES for an hour – voice samples were recorded pre and post TES. The results revealed no remarkable changes in the acoustic voice characteristics after TES application (Gorham-Rowan, Fowler, & Hapner, 2010).

IV. The use of electrical stimulation as the only treatment option for Voice Disorders

The treatment approaches for the management of varied voice disorders used by the speech pathologist includes relaxation, behavioural and vocal function exercises but the use of surface electrical stimulation in isolation without incorporating traditional voice therapy techniques for the treatment of voice disorders is still a query for the professionals.

To examine voice change in healthy individuals', a prospective study was conducted by Fowler and colleagues to gauge changes in fundamental frequency and relative sound levels after the application of Transcutaneous electrical stimulation via VitalStim. Ten healthy males and females were selected, all participants received TES for an hour by following dysphagia therapy protocol; the findings indicated that TES application produces a measurable change in fundamental frequency and relative sound level but still, further research is required as these changes are highly variable. (Fowler, Gorham-Rowan, & Hapner, 2011). A clinical trial was conducted by Silverio et al., in Brazil, they aimed to compare the effects of Transcutaneous electrical nerve stimulation (TENS) and Laryngeal Manual Therapy (LMT) among dysphonic women – Total twenty women with bilateral vocal nodules participated in the trial, all participants were examined based on laryngeal symptoms, musculoskeletal pain and vocal parameters. The participants were divided into two groups with 10 volunteers' in each group, one group received TENS and the other group had LMT application. Both groups had 12 sessions on a biweekly basis, the duration of each session was 20 minutes. Findings of this study indicated that application of TENS has better results in improving the voice quality and reducing pain in the upper back, shoulders and posterior neck therefore in comparison with LMT, TENS can be used as a treatment method complacent to voice therapy (Silverio et al., 2015).

V. Electrical stimulation adjunct with voice therapy

Different researches have been conducted in the past to examine the effectiveness of combined use of electrical stimulation with traditional voice therapy.

In research, the outcomes of traditional voice exercises (VE) with electrical stimulation supported voice exercise (ES) were compared, total ninety patients with unilateral recurrent laryngeal nerve palsy (URLNP) were selected to participate in this prospective randomized clinical trial – the results indicated that electrical stimulation supported voice exercise (ES) was superior to traditional voice exercises (VE) for patients URLNP as a treatment modality (Ptok & Strack, 2008).

Another study was conducted in Egypt, Ras and coworkers wanted to compare the therapeutic effects of transcutaneous electrical stimulation-supported voice therapy (TESVT) and conventional voice therapy (CVT). They randomly selected 29 patients with unilateral vocal fold paralysis then divided the patients into two groups. Group 1 had 14 patients who received CVT and group 2 had 15 patients they underwent TESVT after detailed analysis the results revealed that both treatment modalities have a similar outcome and no significant difference was observed between TESVT and CVT however further research is required with large sample size to confirm this fact. (Ras et al., 2016).

Another randomized clinical trial was carried out by Oliveira Santos and colleagues they wanted to assess the effect of transcutaneous electrical nerve stimulation (TENS) with or without tongue trills among patients with vocal nodules – the results indicated that TENS application with or without tongue trills related to improved glottal closure, better voice quality and effortless phonation (de Oliveira Santos, Silvério, Oliveira, & Gama, 2016).

A study was conducted in Iran by a group of speech pathologists whose aim was to monitor the effects of voice therapy with or without transcutaneous electrical nerve stimulation (TENS). Total twenty women with muscle tension dysphonia participated in the study; they were divided into two groups, one group with ten participants received TENS + voice therapy (VT) the other group with the same number of participants received only voice

therapy. Both groups received therapy for 10 days on a biweekly basis; the session duration was 50 minutes. The results revealed that the group which received TENS + voice therapy has better improvements in vocal tract dysfunction items, all auditory perceptual parameters and shimmer also the intensity of musculoskeletal pain was reduced in the TES + voice therapy group as compared to the voice therapy group, therefore, TENS was recommended as a complementary treatment for patients with muscle tension dysphonia (Mansuri et al., 2018).

In Brazil a recent paper is published by Almeida et al., they conducted a systematic review to assess the effect of electrical stimulation on the treatment of Dysphonia they selected eleven articles that highlighted the impact of neuromuscular electrical stimulation (NMES) and transcutaneous electrical nerve stimulation (TENS) on dysphonia caused by vocal nodules, vocal fold paralysis and spasmodic dysphonia. Results revealed that electrical stimulation cannot be used as an evidence-based treatment modality in the treatment of dysphonia although the review indicated that electrical stimulation had therapeutic effects on various aspects of dysphonia but the biases and heterogeneity of the studies indicated that more authentic researches are required to support this fact. (de Almeida et al., 2020).

VI. Discussion

Behavioural voice therapy is the main treatment approach for different kinds of vocal pathologies that are recommended by speech pathologists worldwide (Desjardins, Halstead, Cooke, & Bonilha, 2016). Since the advent of electrical stimulation as a treatment modality in the management of swallowing disorders – clinicians have noted positive changes in vocal parameters that prompted rehabilitation professionals to conduct prospective clinical trials to assess the effectiveness of electrical stimulation in the treatment of voice disorders. Surface electrical stimulation is a non-surgical method in which electrodes are superficially placed on the neck area to stimulate the laryngeal muscles. There are two types of surface electrical stimulation, Transcutaneous electrical nerve stimulation (TENS) and Neuromuscular electrical stimulation (NMES) - TENS reduces muscle pain and fatigue and improves vascularization as it targets the sensory nerves responsible for sending pain signals to the brain, NMES, on the other hand, stimulates innervating nerve for muscle contraction as it targets the motor nerves.

This integrative literature review was done to find answers to the following questions: Can electrical stimulation improve vocal fold adduction, voice quality and increase loudness; Does the independent application of surface electrical stimulation effective in the treatment of many kinds of voice disorders or the combined use of electrical stimulation with conventional voice therapy has more efficacious results. Different studies from 2008 onwards were selected to answer the above-mentioned queries. According to the literature limited researches were conducted to confirm the hypothesis that electrical stimulation improves vocal fold adduction – according to Humbert and coworkers surface electrical stimulation has no effect on vocal adduction but their study has limited sample and further work is required to confirm this fact. (Humbert et al., 2008) Another study supported the hypothesis that transcutaneous electrical stimulation causes significant vocal adduction (Seifpanahi et al., 2017) however further research is required to support the findings of this study.

Three different research papers stated the effect of electrical stimulation on loudness and voice quality as mentioned above – the findings indicated that there is no significant effect of electrical stimulation on voice quality and loudness also due to biases and limited data on this subject more work is required. The application of electrical stimulation with traditional voice therapy was found to be effective in the treatment of different voice disorders such as muscle tension dysphonia (MTD), vocal nodules, vocal fold paralysis and paresis, spasmodic dysphonia but due to small sample size, selection and confirmation bias, more clinical trials are required to consider electrical stimulation an effective treatment for the management of voice disorders. In this review article we discussed the effectiveness of electrical stimulation in the treatment of voice disorders but to consider surface electrical stimulation as a conventional rehabilitating therapy is still not conclusive therefore further research is required with standard measures.

VII. Conclusion

The review of the present literature supported the conclusion that electrical stimulation along with traditional voice exercises reduces muscle tension and pain in the laryngeal muscles. It also improves loudness, pitch

and voice quality. This modality of treatment was found to be effective among patients with following vocal pathologies such as muscle tension dysphonia, vocal nodules, presbyphonia, vocal fold paralysis and paresis however further research is required with greater sample size to consider electrical stimulation as an evidence-based modality of treatment in voice disorders.

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