CoDAS
ISSN 2317-1782 (Online version)

Systematic Review
Revisão Sistemática

Surface electromyographic biofeedback for behavioral dysphonia in adult people: a systematic review

Biofeedback eletromiográfico de superfície para disfonia comportamental em adultos: revisão sistemática

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Keywords

Dysphonia
Feedback
Therapeutics
Voice
Voice Training

ABSTRACT

Purpose: To review systematically the literature and to analyze the effectiveness of surface electromyographic biofeedback in the rehabilitation of adults with behavioral dysphonia. **Research strategies:** Two authors performed an independent search in the following databases: Clinical Trials, Cochrane Library, Embase, LILACS, PubMed, and Web of Science. A specific search strategy was developed for each database. **Selection criteria:** The review included studies that examined the effectiveness of surface electromyographic biofeedback compared to other direct vocal therapy intervention in adults with behavioral dysphonia. There were no restrictions in regard to language or date of publication. **Data analysis:** Analysis of the risk of bias, heterogeneity, quantitative and qualitative data, sensitivity, subgroups, and publication bias. **Results:** 51 studies were identified, but only two cohort studies remained as prospects for analysis. The studies showed 100% uncertain risk of selection, performance, and detection bias. There was a high degree of clinical heterogeneity. The descriptive analysis showed a reduction in muscle electrical activity and improvement in vocal self-assessment using electromyographic biofeedback; however, it was not possible to calculate the effect size of the interventions. The present study was limited by the fact that it was unable to show a consensus for the majority of data analyzed. **Conclusion:** The available literature does not support a conclusive finding about the effectiveness of surface electromyographic biofeedback compared to other direct interventions used in the rehabilitation of adults with behavioral dysphonia. The studies analyzed vary widely in their clinical procedures and methodology, making it impossible to determine the procedure's effectiveness.

Descritores

Disfonia
Retroalimentação
Terapêutica
Voz
Treinamento Vocal

RESUMO

Objetivo: Revisar sistematicamente a literatura e analisar a efetividade do biofeedback eletromiográfico de superfície na reabilitação de adultos com disfonia comportamental. **Estratégia de pesquisa:** Dois autores realizaram uma busca independente nas bases de dados: *Clinical Trials*, *Cochrane Library*, *Embase*, *LILACS*, *PUBMED* e *Web of Science*. Elaborou-se uma estratégia de busca específica para cada base. **Critérios de seleção:** Foram incluídos estudos que analisaram a efetividade do *biofeedback* eletromiográfico de superfície comparado com outras intervenções de terapia vocal direta em adultos com disfonia comportamental. Não houve restrição de idioma e data de publicação. **Análise de dados:** Análise do risco de viés, heterogeneidade, dados quantitativos e qualitativos, sensibilidade, subgrupos e viés de publicação. **Resultados:** foram identificados 51 estudos, sendo que apenas dois estudos coorte prospectivos foram analisados. Os estudos apresentaram 100% de risco incerto de viés de seleção, performance e detecção. Houve alta heterogeneidade clínica. A análise descritiva mostrou redução da atividade elétrica muscular e melhora da autoavaliação vocal com o uso do *biofeedback* eletromiográfico, porém, não foi possível calcular o tamanho do efeito das intervenções. O presente estudo apresentou limitações por não conseguir apresentar um consenso para a maioria dos dados analisados. **Conclusão:** A literatura disponível não permite gerar uma evidência conclusiva acerca da efetividade do *biofeedback* eletromiográfico comparado a outras intervenções diretas na reabilitação de sujeitos adultos com disfonia comportamental.

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Received: April 06, 2018

Accepted: May 16, 2018

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Financial support: Foundation for the Support of Research of the State of São Paulo (case number 2015/06918-5).

Conflict of interests: nothing to declare.

INTRODUCTION

Behavioral dysphonias are vocal changes arising from one or more changes in the way the voice is produced or used, and it can be related to improper vocal habits or techniques, excessive muscle tension, or vocal misuse and abuse[1]. These dysphonias are commonly associated with voice disorders, such as upper airway disorders; increased tension or mass in the vocal folds that causes postural changes or benign lesions on these folds; tense, rough, whispery, or unstable voice quality; laryngeal or pharyngeal resonance; and restricted articulation[1-5]. They can also be related to alterations in the tension or function of the shoulder girdle or perilaryngeal muscles[3-12].

Vocal rehabilitation of behavioral dysphonia can take two forms: direct or indirect[13-15]. The purpose of the indirect approach is to help the individual to understand the use of his or her voice and to develop strategies that minimize risk factors and promote healthy vocal use, as well as to understand the psychodynamic aspects of the voice and the effect that his or her voice has on the listener. The direct approach is employed in order to change vocal behavior through practicing vocal techniques and exercises, ranging from production by itself to its association with function, with the goal of achieving an efficient, normative use of the voice.

One example of a direct approach to vocal rehabilitation for behavioral dysphonia is surface electromyographic biofeedback[16-18]. Surface electromyographic biofeedback was first used in the 1960's as a therapeutic resource in the field of physical therapy, and the first reports of studies applying the procedure to vocal therapy appeared in 1978[19].

This technique motivates the participant to (re)learn the muscle coordination of the phono-articulatory organs, making permanent changes to this neuromuscular behavior by monitoring, visualizing, and controlling the signs of the electrical activity of muscles displayed on a screen for the patient, who attempts to achieve a target set by the therapist. It is believed that this occurs due to the plasticity of the central nervous system, which allows an individual to adapt to a new demand through neuro-functional reorganization and then transfer this new behavior to his or her daily life[20,21].

In vocal rehabilitation, the practice of vocal exercises is combined with surface electromyographic biofeedback to help participants visually and kinesthetically self-monitor their vocal production[18]. It is believed that this combination can facilitate a change in vocal behavior and encourage medium- and long-term maintenance of well-balanced vocal production[18].

In general, therapeutic programs that applied biofeedback to vocal therapy showed a reduction in electrical activity of muscles in the region of the extrinsic laryngeal muscles and shoulder girdle[16,18,20,22-25] and improvements in voice quality[17,22], vocal self-assessment[16], and laryngeal anatomy and physiology, with resorption of benign nodular lesions[22]. The literature indicates that the procedure can aid in maintenance of therapeutic effects over the medium-[17,22] and long-term[16]. However, there is no consensus regarding the duration, number, and frequency of treatment sessions using surface electromyographic biofeedback, or regarding the activities to be undertaken during its application, hindering its clinical applicability.

Thus, there is a demonstrated need for an analysis of the best scientific evidence available in the literature regarding the application of surface electromyographic biofeedback in the treatment of adults with behavioral dysphonia, providing a general overview of the procedure's applicability and effectiveness from a clinical point of view and from the patient's perspective, comparing it to other direct vocal therapy procedures. It is believed that this data may aid clinical decision-making and guide speech therapy in cases of adults with behavioral dysphonia.

OBJECTIVES

To review systematically the literature and to analyze the effectiveness of surface electromyographic biofeedback in vocal rehabilitation of adults with behavioral dysphonia.

RESEARCH STRATEGIES

The study consists of a systematic review. The present methodology followed the recommendations of the Cochrane Library and PRISMA. The underlying clinical question that structured the present study is the following: "How effective is surface electromyographic biofeedback compared to other direct vocal therapy interventions in the vocal rehabilitation of adults with behavioral dysphonia?"

A systematic search for studies was performed, without restriction as to language or date of publication up to December 2016, for studies that had already reported results and were available in their full version on the Clinical Trials, Cochrane Library, Embase, LILACS, PubMed, and Web of Science databases. A specific search strategy was developed for each database, based on keywords related to PICO (Chart 1). The electronic search was supplemented by a manual search, conducted by scanning the references of the selected articles.

Chart 1. Search strategy for identifying studies

Database	Uniterms	Search strategies
Clinical Trials	MeSH	(("Dysphonia" OR "Voice Disorders") AND ("Therapeutics" OR "therapy" OR "Rehabilitation" OR "Exercise Therapy" OR "Rehabilitation of Speech and Language Disorders" OR "Voice Training") AND ("Biofeedback, Psychology" OR "Feedback" OR "Neurofeedback" OR "electromyographic biofeedback"))
Cochrane Library	MeSH	((("clinical" AND "trial") OR "clinical trials as topic" OR "clinical trial" OR "random*" OR "random allocation" OR "therapeutic use") AND ("Dysphonia" OR "Voice Disorders") AND ("Therapeutics" OR "therapy" OR "Massage" OR "Musculoskeletal Manipulations" OR "Rehabilitation" OR "Rehabilitation of Speech and Language Disorders" OR "Voice Training"))
LILACS	DeCS	dysphonia OR voice disorders AND therapeutics OR rehabilitation OR rehabilitation of speech and language disorders OR voice training AND feedback OR biofeedback, psychology OR electromyography OR biofeedback electromyography
PUBMED	MeSH	((((((clinical[Title/Abstract] AND trial[Title/Abstract]) OR "clinical trials as topic"[Mesh] OR (clinical trial [Publication Type]) OR "random"*[Title/Abstract] OR "random allocation"[Mesh] OR "therapeutic use"[MeSH Subheading]))))) AND (("Voice Disorders"[Mesh] OR "Dysphonia"[Mesh]))) AND (("Therapeutics"[Mesh] OR "therapy"[Subheading] OR "Rehabilitation"[Mesh] OR "rehabilitation" [Subheading] OR "Exercise Therapy"[Mesh]) OR "Rehabilitation of Speech and Language Disorders"[Mesh] OR "Voice Training"[Mesh])) AND (("Biofeedback, Psychology"[Mesh] OR "Feedback"[Mesh] OR "Neurofeedback"[Mesh] OR "electromyographic biofeedback"[Title/Abstract]))
Web of Science	MeSH	("clinical" AND "trial") OR "clinical trials as topic" OR "clinical trial" OR "random*" OR "random allocation" OR "therapeutic use" AND "Dysphonia" OR "Voice Disorders" AND "Therapeutics" OR "therapy" OR "Rehabilitation" OR "Exercise Therapy" OR "Rehabilitation of Speech and Language Disorders" OR "Voice Training" AND "Biofeedback, Psychology" OR "Feedback" OR "Neurofeedback" OR "electromyographic biofeedback"
Embase	Emtree	'clinical trial'/exp OR 'clinical trial' OR 'clinical study'/exp OR 'clinical study' OR 'clinical article'/exp OR 'clinical article' OR 'clinical trial (topic)'/exp OR 'clinical trial (topic)' OR 'controlled clinical trial'/exp OR 'controlled clinical trial' OR 'controlled clinical trial (topic)'/exp OR 'controlled clinical trial (topic)' OR 'randomized controlled trial'/exp OR 'randomized controlled trial' OR 'controlled study'/exp OR 'controlled study' OR 'pretest posttest control group design'/exp OR 'pretest posttest control group design' OR 'intervention study'/exp OR 'intervention study' AND ('dysphonia'/exp OR 'dysphonia') OR 'voice disorder'/exp OR 'voice disorder' AND ('therapy'/exp OR 'therapy') OR 'rehabilitation'/exp OR 'rehabilitation' OR 'exercise'/exp OR 'exercise' OR 'speech and language rehabilitation'/exp OR 'speech and language rehabilitation' OR 'voice training'/exp OR 'voice training' AND ('feedback system'/exp OR 'feedback system') OR 'neurofeedback'/exp OR 'neurofeedback' AND ('electromyograph'/exp OR 'electromyograph')

SELECTION CRITERIA

The inclusion criteria considered were as follows:

Design: the study was designed to include the greatest possible amount of data that had at least one study available, including randomized clinical trials and prospective cohort and retrospective cohort studies.

Participants (P): adults with behavioral dysphonia - voice disorders that has its etiology related to the use of voice[1].

Intervention (I): surface electromyographic biofeedback.

Control group (C): other direct vocal therapy interventions - interventions applied directly to the voice production apparatus[13].

Outcomes (O): (1) Surface electromyography: electrical activity of the infrahyoid, suprahyoid, trapezoid, sternocleidomastoid, thyroid region, cricothyroid region, and orofacial region muscles is measured as a continuous quantitative variable. The mean values of the electrical activity of muscles were quantified in root mean square (RMS) during the activity of phonation. (2) Perceptual evaluation of voice quality using the parameter of overall level of vocal deviation: dichotomous classification as better (voice improved after the intervention) or unchanged/worse (voice remained the same or worsened after the intervention). To homogenize the data, they were transformed into dichotomous categorical variables: better or unchanged/worse. On a Likert scale, a one-degree reduction was considered better, maintenance of the same degree was considered unchanged, and a one-degree increase was considered worse. On a visual analogue scale, a ten-point difference was considered a change[26]; that is, an increase of at least 10 points was considered worse, a reduction of at least 10 points was considered better, and a difference of less than 10 points was considered unchanged. (3) Vocal self-perception: a dichotomous classification as better (reduction in the intensity of pain following the intervention or unchanged/worse (vocal self-perception remained the same or worsened following the intervention). For the data analyzed using a Likert scale, a one-degree reduction was considered better, maintenance of the same degree was considered unchanged, and a one-degree increase was considered worse. When a measurement was taken more than once pre- and post-therapy, a degree was considered for each time the question was answered.

DATA ANALYSIS

The selection of studies was carried out by two authors working independently in February 2017. The order of procedures for identifying potentially relevant studies and applying the present study's selection criteria was the following: reading the titles, reading the abstracts, and reading the articles in their entirety. The analysis of concordance between the authors' selections showed 94.74% concordance (Kappa= 0.77). In situation of disagreement, analysis was made by consensus. The two articles over which the authors disagreed were entirely reread and discussed by the authors, resulting in their exclusion from the study by consensus.

The data analysis was conducted in the following order: analysis of the risk of bias; assessment of heterogeneity (statistical and clinical); analysis of the quantitative data (descriptive analysis of data regarding the outcomes and assessment of the degree to which the treatment was responsible for the outcomes); analysis of the qualitative data (descriptive analysis of the qualitative data: authors, database, journal, year, design, country, sample, pathology, gender, age, number of sessions, frequency of sessions, duration of sessions, muscles targeted by surface electromyographic biofeedback, format in which the surface electromyographic biofeedback was presented, and the activities carried out during the surface electromyographic biofeedback process); and analysis of sensitivity, subgroups, and publication bias. Methodological heterogeneity was not analyzed, as all the studies selected were similarly designed. The risk of bias was analyzed using the classification proposed by the Cochrane Library[27] and the Cochrane Review Manager 5.3 software. The analysis of clinical heterogeneity was based on two variables: the combination of surface electromyographic biofeedback therapy with direct vocal therapy (vocal function exercise) and the combination of surface electromyographic biofeedback therapy with indirect vocal therapy (vocal counseling and psychodynamic aspects).

RESULTS

Figure 1 shows that 57 studies were identified in the databases (Central Cochrane: 22; Clinical Trials: 4; Embase: 19; LILACS: 3; PubMed: 8; Web of Science: 1), and 13 were identified through a manual search, totaling 70 studies. During the first stage, 53 studies were excluded based on the title and abstract, and one duplicate study was eliminated. A total of 16 studies relevant to the topic were found, of which 11 were excluded due to their design and three were excluded due to their population. Thus, two studies on the use of surface electromyographic biofeedback in the vocal rehabilitation of adults with behavioral dysphonia were chosen.

In the authors' judgement, the risk of bias of each included study demonstrated that both studies showed uncertain risk of bias in the randomization and allocation of participants, the masking of the patients and personnel, and the masking of the assessors (Figure 2). Thus, the present study shows 100% uncertain risk of bias regarding selection, performance, and detection biases (Figure 3).

The assessment of heterogeneity in clinical practices shows that all the studies (100%; n= 2) combined surface electromyographic biofeedback with vocal functions, 50% (n= 1) combined it with vocal exercises, 50% (n= 1) conducted vocal counseling, and none of the studies worked with psychodynamic vocal aspects (n= 0; 0%) (Table 1).

A descriptive analysis of data on the outcomes (Table 2) shows that there was reduction of the electrical activity of muscles and improvement of vocal self-evaluation, but it was not possible to perform a meta-analysis of the data since there was no common outcome between the studies, which made it impossible to calculate the degree of the interventions' effectiveness or the statistical heterogeneity. No studies were found that assessed outcomes related to the electrical activity of the infrahyoid, suprahyoid, trapezius, and sternocleidomastoid muscles, nor to auditory-perceptual analysis of the voice.

Chart 2 shows the qualitative analysis of the characteristics of the publication, the sample, and the intervention.

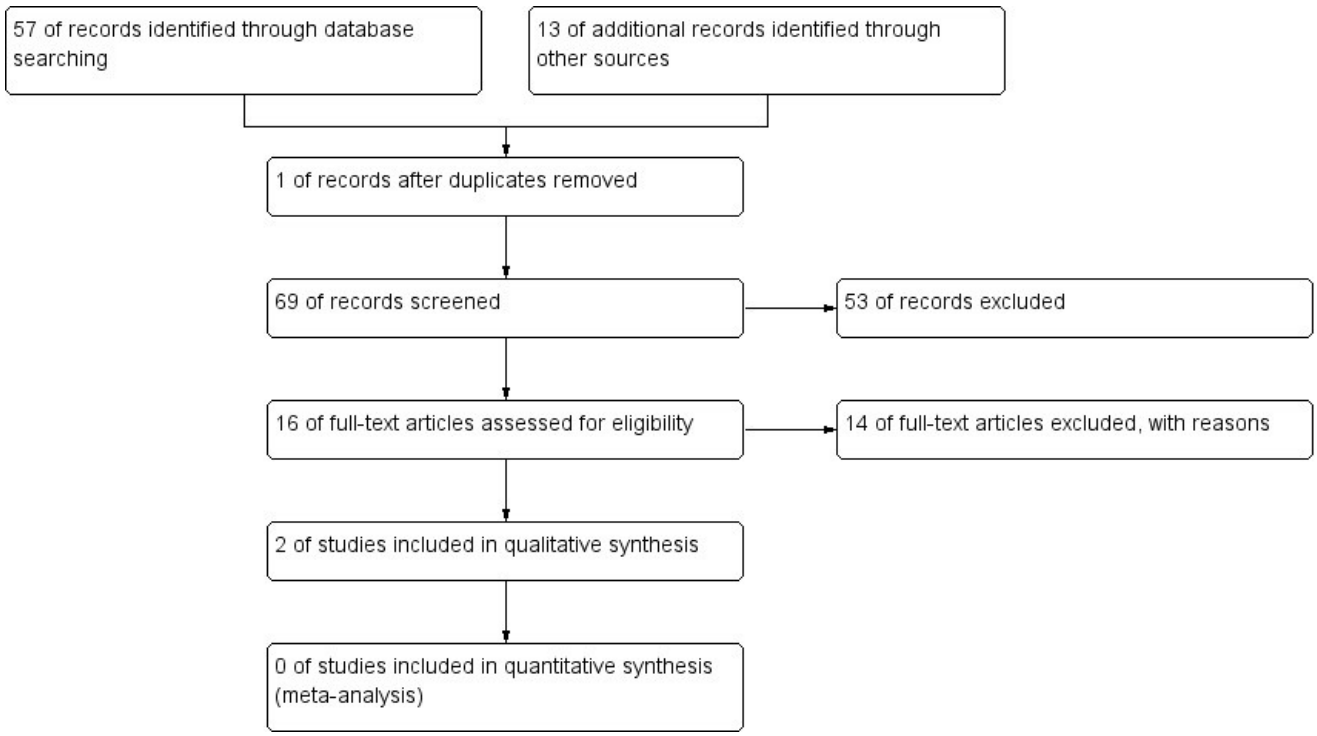

Figure 1. Search diagram for the selection of studies

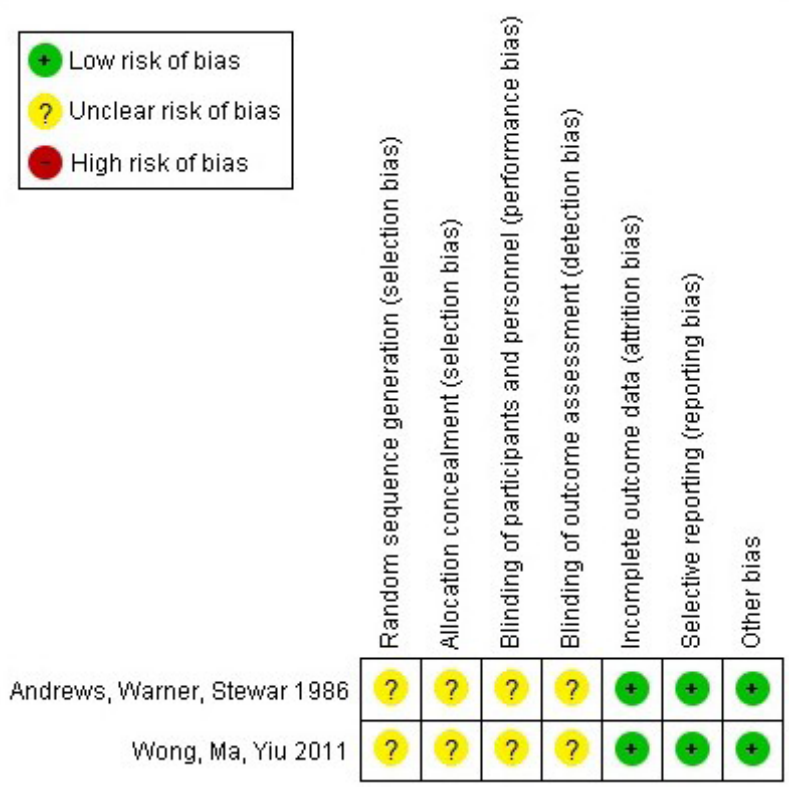

Figure 2. Risk of bias summary: review of the authors' judgements about each risk of bias item for each included study

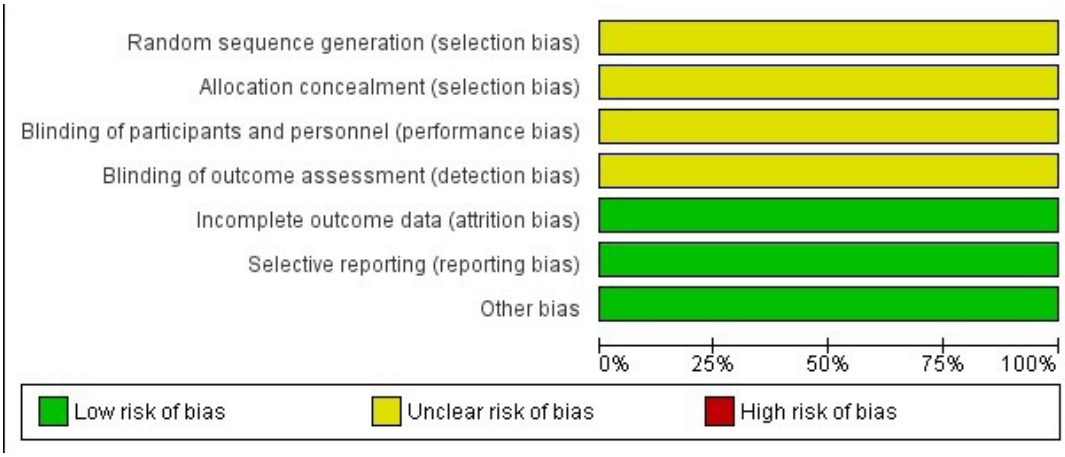

Figure 3. Risk of bias graph: review of the authors' judgements about each risk of bias item presented as percentages across all included studies

Table 1. Assessment of the clinical heterogeneity of the studies

Parameters analyzed	Subgroups	n	%
Surface electromyographic biofeedback program combined with direct vocal therapy	Exercise	1	50.00
	Function	2	100.00
Surface electromyographic biofeedback program combined with indirect vocal therapy	Vocal counseling	1	50.00
	Vocal psychodynamics	0	0.00

Descriptive analysis of the frequency of occurrence
Caption: n = number of studies; % = percentage of study

Table 2. Descriptive analysis of outcomes data

AUTHORS	Wong AY, Ma EP, Yiu EM[18]	Andrews S, Warner J, Stewart R[28]
Surface electromyography of the oral-facial region during habitual phonatory activity	Group 1 (biofeedback combined with constant practice)—pre: 37.53 ± 9.03; post: 30.78 ± 8.76; Group 2 (biofeedback combined with masked practice)—pre: 34.13 ± 11.96; post: 30.98 ± 12.78; Group 3 (biofeedback combined with randomized practice)—pre: 32.81 ± 15.19; post: 28.86 ± 9.82	NA
Surface electromyography of the thyroid-hyoid region during habitual phonatory activity	Group 1 (biofeedback combined with constant practice)—pre: 20.24 ± 4.11; post: 14.71 ± 3.82; Group 2 (biofeedback combined with masked practice)—pre: 16.98 ± 3.62; post: 12.33 ± 1.90; Group 3 (biofeedback combined with randomized practice)—pre: 21.10 ± 3.80; post: 15.00 ± 3.26	NA
Surface electromyography of the cricothyroid-hyoid region during habitual phonatory activity	NA	Group 1 (biofeedback)—pre: 204.20 ± 147.34; post: 12.60 ± 3.97; Group 2 (program of progressive relaxation)—pre: 138.6 ± 95.84; post: 24.40 ± 4.92
Auditory-perceptive assessment	NA	NA
Vocal self-assessment	NA	Group 1 (biofeedback)—Improved= 5; No change/Worse= 0; Group 2 (program of progressive relaxation)—Improved= 4; No change/Worse= 1

Caption: NA = outcome was not assessed in the article

Chart 2. Qualitative analysis of the data

Authors	Wong AY, Ma EP, Yiu EM[18]	Andrews S, Warner J, Stewart R[28]
Database	Cochrane and PubMed	Manual search
Journal	Journal of Voice	British Journal of Disorders of Communication
Year	2011	1986
Design	Prospective cohort	Prospective cohort
Country	China	England
Sample	Group 1 (biofeedback combined with constant practice): 7 participants; Group 2 (biofeedback combined with practice): 7 participants; Group 3 (biofeedback combined with randomized practice): 7 participants	Group 1 (biofeedback): 5 participants; Group 2 (program of progressive relaxation): 5 participants
Pathology	Hyperfunctional dysphonia	Hyperfunctional dysphonia
Gender	Both sexes	Female
Age	18-48 years	20-54 years
Number of sessions	8 sessions	4-15 sessions
Frequency of sessions	Twice per week	Once per week
Duration of session	ND	45 minutes
Muscles of electromyographic biofeedback	Muscle of the thyroid-hyoid region	Muscle of the cricothyroid region
Format of electromyographic biofeedback presentation	Visual feedback in the form of the electrical activity reading in RMS appearing on the computer screen after every two sentences	Visual feedback in the form of electrical activity reading as registered by a needle on a scale
Activity performed during the electromyographic biofeedback	Reading aloud a set of 24 sentences in three ways: constant number, increasing number, and random number of characters	Reading with maximum electrical activity below 30 μV in four of five consecutive tests to pass to phonation tasks; in subsequent stages, reading with electrical activity varying by no more than 10μV from a resting state in four of five tests

Caption: ND = no data in the article

Due to the uncertain risk of bias, the high degree of clinical heterogeneity and the lack of common outcomes among the studies, it was not possible to perform a sensitivity analysis of subgroups and publication bias.

DISCUSSION

A total of 51 studies were identified (Figure 1), of which, 16[16-20,23-25,28-35] were relevant to the topic. When the complete articles were read and the selection criteria for this study were applied, the study's design excluded 11 articles[16,17,19,24,29-35]. Of the five prospective cohort studies found[18,20,23,25,28], two examined vocally healthy individuals[20,25] and another examined singing students, without mentioning their vocal health[23]; therefore, these did not meet the eligibility requirements for inclusion in the present study. Consequently, only two studies that examined dysphonic individuals were included[18,28].

The assessment of the risk of bias is a subjective analysis of methodological considerations that are of sufficient magnitude to impact the study's conclusions[27]. Therefore, this analysis indicates the reliability of the findings and the risk posed by generalizing the scientific evidence of the reviews and basing decisions regarding clinical procedures on them. The studies selected for this review[18,28] showed uncertain risk of selection, performance, and detection biases (Figure 2).

The older study[28] demonstrates an uncertain risk of selection bias because the authors describe a combination of ten individuals who make up the sample in five pairs. Subsequently, they were randomly allocated in two groups, and the pairs were separated, with one assigned to each group. No detail is provided about the method used to carry out and mask the allocation process. The uncertain risk of performance bias occurred because the study reports that patients were blinded to the existence of another program of treatment, but it does not specify whether the study personnel were similarly blinded. The uncertain risk of detection bias was due to the lack of information regarding how the outcome assessors were blinded in regard to the intervention.

In the more recent study[18], the uncertain risk of selection bias occurred because the authors wrote that the participants were equally and randomly assigned to groups, but they included no information about the method used to perform and mask the allocation of the participants. The uncertain risk of performance bias occurred because the study does not report whether the participants and personnel were blinded regarding the intervention's methods. The uncertain risk of detection bias was due to the absence of information related to the implementation and method of blinding outcome assessors in the various interventions.

Thus, the present literature review presents a 100% uncertain risk of selection, performance, and detection biases (Figure 3). Thus, it is observed that in addition to the scarcity of studies regarding use of surface electromyographic biofeedback in rehabilitation of adults with behavioral dysphonia, the available studies have a low level of scientific evidence. Consequently, despite the limitations, it is important to analyze the scientific evidence available on the topic.

The assessment of clinical heterogeneity (Table 1) shows that the only common elements between the studies were the combination of surface electromyographic biofeedback with tasks of phonatory function and no association with treatment involving vocal psychodynamic. The studies differed in their combination of biofeedback with vocal exercises and in procedures of vocal counseling, which were performed by only one study[28]. A high degree of clinical heterogeneity was observed in regard to the tasks associated with the use of surface electromyographic biofeedback in the rehabilitation of adults with dysphonia.

There were no common outcomes shared by the studies, which made it impossible to calculate their statistical heterogeneity and the degree of effectiveness of the interventions (Table 2). Descriptive analysis of the outcomes reveals a reduction in the electrical activity in the thyroid[18], orofacial[18] and cricothyroid region[28], and improvement in vocal self-assessment[28], both in biofeedback and control groups. However, it is not possible to perform meta-analysis to determine if the surface electromyographic biofeedback is more effective than other procedures of direct vocal therapy in rehabilitation of adults with behavioral dysphonia.

A recent review of the literature[15] on the effectiveness of vocal therapy showed that only 15 of the 3,290 studies identified were clinical trials that met the selection criteria. The studies covered behavioral and organic dysphonias and seven behavioral approaches using specific vocal therapies. Most of the studies showed significant improvement following the intervention, but the clinical significance of the results was usually not discussed. Moreover, the study also found discrepancies in the outcomes analyzed, which made it difficult to compare the studies. Accordingly, the study[15] found results similar to those of this systematic review, so there seems to be a complete lack of clinical trials and methodologically rigorous studies in the field of voice therapy. The heterogeneity of procedures found in the few available studies hampers efforts at systematic reviews in the field, which reduces the possibility of creating a scientifically rigorous protocol of clinical and therapeutic procedures to aid clinical care in the field of voice, and, in this case, specifically for the therapeutic use of surface electromyographic biofeedback.

It was observed that one of the studies was found in two databases[18], and one was found through a manual search[28]. These results demonstrate the importance of conducting a broad search of the most important databases and supplementing it with a manual search, primarily by scanning the references in the studies found. This supplementary search is important to identify additional relevant articles, especially older articles that are unlikely to show up in search strategies or are not available in electronic databases[27]. This is the only way to conduct a broad systematic review of the literature that includes all the available data on the subject.

The more recent article[18] was published in the Journal of Voice in 2011, and the older[28] one was published in 1986 in the British Journal of Disorders of Communication, currently the International Journal of Language & Communication Disorders. Both are designed as prospective cohort studies[18,28], with one conducted in China[18] and the other in England[28]. The prospective cohort study is one of the clinical research designs of the medical

field with the highest level of scientific evidence, surpassed only by large-scale trials and randomized clinical trials; no studies of this nature that addressed the key question of this review were found[36]. Beyond the design, however, a number of other methodological precautions are necessary to ensure that there is no risk of bias in the findings obtained[27].

The characteristics of the sample show that both studies[18,28] examined adults with hyperfunctional dysphonia. One of the studies examined three groups of seven individuals of both genders[18], and the other[28] analyzed two groups of five individuals, all female. Thus, homogeneity was observed in the characteristics of both study samples. Both studies show that biofeedback is a procedure recommended for the treatment of vocal behavior disorders, which are characterized primarily by muscular hyperfunction or hypertension[16-18,22,30]. These findings are confirmed by a review of the literature[33] that sought to identify the effects of all types of biofeedback therapy on phonatory disorders and phonatory performance. The study[33] showed that, in general, biofeedback is effective in improving dysphonia or is more effective than traditional voice therapy. The authors conclude that the method seems to aid in the reduction of laryngeal tension and is effective for cases arising from muscle tension. However, it does not seem to help in cases of healthy participants or when the problem is associated with psychological components[19], since this is a procedure based on the modification of neuromuscular behavior. The authors believe this occurred because there is no direct relationship between surface electromyographic biofeedback and vocal quality, but rather between surface electromyographic biofeedback and hyperfunction of the muscles involved in phonation.

The small number of subjects in each group analyzed limits the findings, since the smaller the sample, the less likely it is that significant statistical difference between the procedures will be found. Regarding gender, studies that analyze only females are common. This may be explained by the ease of recruiting female participants, since women are more likely to seek health services and more likely to complain of voice disorders due to their anatomical and physiological predisposition[3,8].

One study consisted of eight sessions[18], and the number of sessions in the other study varied from 4 to 15[28], according to the degree of dysphonia. The 45-minute sessions[28] occurred once[28] or twice[18] per week. One of the studies did not report the duration of the sessions[18]. Thus, one can observe no uniformity in the temporal variables related to surface electromyographic biofeedback therapy. Although clinical reality confirms that the time of a session varies by individual and is directly related to the degree of dysphonia[28], no other studies have yet been found that grouped and analyzed individuals who underwent a different number of sessions. These differences adversely affect the analysis of the data, particularly when the study has such a small sample. The absence of important information such as the duration of the sessions[18] also makes it difficult to replicate the study.

In general, there is a lack of standardization among studies of the use of biofeedback in voice rehabilitation treatment, with the number of sessions varying from 8 to 16[17]. One study[20] recommended four sessions of direct vocal therapy using traditional techniques, followed by three sessions of biofeedback with cognitive-behavioral therapy[16]. The frequency of sessions varied from twice a week[20] to twice a month[17], and the duration varied from 25[17] to 90 minutes[16].

Although heterogeneous, the present study's data resemble the findings of a synthesis of the literature[37] and a systematic review of the literature[15] on vocal rehabilitation. The synthesis of the literature[37] analyzed 140 studies, totaling 2,596 cases, published between 1975 and 2013 in the scientific literature of the field of voice, showing that the process of vocal rehabilitation includes, on average, 10.87 sessions. Studies involving weekly 30-minute sessions were most common. The systematic review of the literature[15], on the other hand, analyzed 15 studies, totaling 672 cases, and showed that, on average, they consisted of 10.5 sessions of 45 to 60 minutes twice per week.

A study that compared individuals who concluded the therapeutic program to others who quit treatment before completing the rehabilitation program showed a difference between the two groups. Individuals who concluded the therapeutic program had a shorter interval between referral and therapy and underwent a greater average of number of sessions. The study found that individuals who underwent an average of 4.8 sessions or more had a greater chance of completing therapy, which lasted 11 sessions at most[38]. Thus, therapeutic programs that include more than five sessions have a greater chance of success, such as the more recent study of biofeedback[18] analyzed in this review. Moreover, considering that the main goal of biofeedback is to (re)learn vocal behavior, it takes longer to adapt to a new demand, which begins as a voluntary process. Thus, depending on the plasticity of the central nervous system, a neurofunctional reorganization occurs, and the individual starts to perform the vocal behavior automatically[18,21].

In regard to the application site of electrodes for biofeedback, in one of the studies, the electrode was applied in the thyroid region[18], and in the other study, it was applied in the cricothyroid region[28] (Chart 2). In one of the studies, the visual feedback was provided on a computer screen which, at two-sentence intervals, showed the value of the electrical activity in RMS[18]. The other study used a scale with a needle indicating the value of the electrical activity[28], but the studies did not report how the value of the electrical activity of muscles was calculated.

One of the studies used biofeedback while the patient read a set of 24 sentences aloud in three different ways, varying the number of characters of the sentences[18]. The other study set a goal of maximum electrical activity readings below 30 μV in four of five consecutive tests, with the patient performing phonation exercises; the goal of the subsequent stage was maximum electrical activity readings below 10 μV in four of five tests with the patient at rest[28] (Chart 2).

In one of the studies[18], participants in the constant practice group read aloud stimuli consisting of four Chinese characters. The participants in the masked group were instructed to read aloud stimuli of increasing length, consisting of two to five characters. The participants of the random practice group read sentences of varied length, ranging from two to five characters, randomly presented. After every two sentences, this group was shown the electrical activity readings from the thyroid-hyoid

region on a monitor and asked to use this visual feedback to reduce these values by relaxing their neck muscles.

The other study[28] began with oral directions to all participants. In this study, the groups differed regarding the method of relaxing their laryngeal muscles. To achieve relaxation, the participants using biofeedback were instructed to perform a reading activity, during which they were shown the electrical activity registered by a needle on a scale, with instructions to maintain it steadily with a maximum reading below 30 μV in four out of five consecutive attempts. They were given no guidance on how to stabilize or reduce the electrical activity. In subsequent stages, the reading could have a variation of up to 10 μV compared to readings of electrical activity obtained at rest, in addition to other procedures of continuous feedback recommended by Gaarder[39]. Each stage and session were concluded with a test without biofeedback to ensure that the muscle control had been consolidated at that level. After achieving relaxation, both groups received vocal training in which they performed exercises by themselves and in combination with phonation tasks (Chart 2).

Just as the present study found variations in the ways biofeedback was presented and monitored, other studies that used the procedure similarly showed no standardization of the activities conducted during the biofeedback sessions. Some studies used reading aloud from a set of 24 sentences[20,25], while others used singing activities with variation in pitch and volume[23,24,31,32], vocal rest, number counting, or spontaneous speech[17]. One case study included not only the recommendation to reduce muscular activity but also a detailed description of the therapeutic goals set, namely, to reduce the activity by 5μV below the average of the three previous sessions, aiming for a reduction of 5μV per session[17]. The study provided no explanation for the parameters adopted based on muscle function or on the physiology of the exercise.

Considering that evidence-based medicine is a scientific practice aimed at answering clinical questions and providing data to guide clinical decision-making, the task is made more difficult by studies with small samples, heterogeneous clinical procedures, variations in musculature, forms of control, implementation and presentation of results, and the absence of important methodological information. Thus, the present study is believed to be limited by its inability to present a consensus on most of the data analyzed due to a lack of studies and the heterogeneity of the few existing data.

Controlled and randomized clinical tests are therefore needed to analyze the effects of applying the surface electromyographic biofeedback in cases of adults with behavioral dysphonia and to provide data to further the discussion on whether this procedure is advisable in vocal rehabilitation.

CONCLUSION

This study concludes that it is not possible to analyze the effectiveness of surface electromyographic biofeedback compared to other direct interventions in the rehabilitation of adults with behavioral dysphonia due to the limited number of studies on surface electromyographic biofeedback. The studies found vary widely in their clinical procedures and methodology, making it impossible to analyze the degree of the procedure's effectiveness.

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Author contributions

VVR: delimitation of the study, data collection, data analysis, writing of the study; JSV: data collection, writing of the study; HMH: delimitation of the study, writing and review of the study; AGB: writing and review of the study; KCAS: delimitation of the study, data analysis, writing and review of the study.