Integration of Dysphagia Therapy Techniques into Voice Rehabilitation: Design and Content Validation of a Cross-Therapy Protocol

[*,†]Carlos Calvache, [*]Nicolás Castillo-Triana, [†,‡]Fernando Delprado Aguirre, [§]Paola Leguízamo, [¶]Sandra Rojas, [†]Pahola Valenzuela, [‖]Mónica Morales Piedrahita, [‖]Maria del Pilar Ramirez Ardila, and [†,**]Dalia Vanessa Ballesteros Pérez, *†§** *Bogotá,* ‡*Medellín,* ‖*Cartagena, Colombia, and* ¶*Santiago, Chile*

Summary: Background. The intricate relationship between swallowing and phonation, sharing anatomical and physiological substrates, underscores a clinical demand for integrated therapeutic approaches. Existing interventions often address these functions in isolation, overlooking their interconnected dynamics.

Objective. To design and validate a cross-therapy protocol incorporating dysphagia therapy techniques (maneuvers/exercises) into voice rehabilitation. This protocol aims to exploit the shared biomechanical components of swallowing and phonation to improve both functions simultaneously in patients with underlying hypofunctional laryngeal pathology.

Methods. A descriptive research design was employed, consisting of three phases: a comprehensive literature review and expert discussions in a German seminar format to conceptualize the protocol; detailed analysis and categorization of swallowing maneuvers/exercises; and content validation by a panel of seven experts through a structured evaluation instrument. The process integrated motor learning and exercise physiology principles to ensure the protocol's clinical applicability and theoretical coherence.

Results. The developed cross-therapy protocol incorporates four core swallowing therapy techniques to voice therapy procedures. Selected swallowing therapy techniques target laryngeal excursion and vocal fold closure because they are critical components of swallowing and phonation. Expert validation yielded a Content Validity Coefficient exceeding 0.90 for most items, indicating high consensus on the protocol's relevance, clarity, and applicability. Adjustments were made based on feedback, enhancing the protocol's precision and user-friendliness.

Conclusion. We present a novel, evidence-based therapy protocol for voice and swallowing difficulties resulting from hypofunctional laryngeal pathology. Its development marks a significant step toward bridging the gap between swallowing and voice therapy. Future empirical studies are needed to assess its effectiveness in clinical settings.

Key Words: Cross-therapy protocol–Swallowing maneuvers–Voice rehabilitation–Dysphagia–Dysphonia.

INTRODUCTION

Swallowing and phonation share anatomical[1] and physiological[2,3] substrates, including the laryngeal muscles, neural control mechanisms, and structural components of the pharynx and larynx. Airway protection during swallowing requires the adduction of both false and true vocal folds, arytenoid anteriorization, epiglottic inversion, and laryngeal excursion.[4,5] Similarly, during phonation, especially during voice pitch elevation, laryngeal excursion is also required, in addition to the adduction of the true vocal folds,[2,6] thus highlighting the interconnectedness of these processes. In patients with laryngeal pathologies, such as vocal fold paralysis, laryngeal muscle tension, post endotracheal intubation laryngeal injuries, or laryngeal cancer, concurrent swallowing and voice disorders are often observed.[7–10] Furthermore, dysphonia has been shown to be a relatively good predictor of aspiration risk in stroke patients,[11] and voice changes after swallowing, like "wet voice," are used as indicators of swallowing dysfunction in swallowing clinical evaluation and dysphagia screening tools.

Some therapy programs targeting voice disorders have been reported to benefit swallowing function,[12] while some swallowing rehabilitation programs have demonstrated improvements in vocal parameters.[13–16] Pitch elevation or pitch glide is part of some swallowing rehabilitation programs,[17,18] and its deterioration has been linked to the occurrence of aspiration events in patients with dysphagia.[19,20] Additionally, Respiratory Muscle Training (RMT), a swallowing therapy program, has improved acoustic voice parameters such as shimmer percentage, amplitude perturbation quotient, and voice turbulence

Accepted for publication July 22, 2024.

This work is funded by Corporación Universitaria Iberoamericana, under research grant for project 202310D040 "Cross therapy protocol for mechanical rehabilitation of phonation and swallowing, applying principles of exercise physiology."

From the *Corporación Universitaria Iberoamericana, Department Communication Sciences and Disorders, Bogotá, Colombia; †Vocology Research, Vocology Center, Bogotá, Colombia; ‡Fundación Universitaria María Cano, Speech Therapy Program, Medellín, Colombia; §Escuela Colombiana de Rehabilitación, Speech Therapy Program, Bogotá, Colombia; ¶Escuela de Fonoaudiología, Facultad de Odontología y Ciencias de la Rehabilitación, Universidad San Sebastián, Santiago, Chile; ‖Universidad de San Buenaventura, Speech Therapy Program, Cartagena, Colombia; and the **Innovación en Fonoaudiología S.A.S., Bogotá, Colombia.

Address correspondence and reprint requests to Carlos Calvache, Corporación Universitaria Iberoamericana, Department Communication Sciences and Disorders, Bogotá, Colombia. E-mail: cabbeto@gmail.com

Journal of Voice, Vol xx, No xx, pp. xxx–xxx

0892-1997

https://doi.org/10.1016/j.jvoice.2024.07.024

index in stroke patients.[15] In patients with muscular tension dysphonia, RMT has positively affected the acoustic index of dysphonia (Cepstral/Spectral Index of Dysphonia) after treatment[16] and has assisted singers in increasing pitch range and phonation duration.[21]

Research on the vocal effects of the Shaker Exercise (SE), a dysphagia exercise option,[22] has found limited effects on the voice of patients with head and neck cancer,[23] but positive effects on vocal range[24] and the dysphonia severity index in healthy older adults.[13] Additionally, indirect laryngeal manipulation maneuvers, not intended for swallowing, such as the Cricothyroid Visor Maneuver[25] and the Low Mandible Maneuver, have shown effects in dysphonia rehabilitation[26,27] demonstrating the potential of indirect laryngeal biomechanics manipulation to improve vocal production.

As was mentioned above, the close relationship between phonation and swallowing is well-recognized when considering laryngeal activity. In the context of dysphagia rehabilitation, more exercises or maneuvers than previously mentioned have proven effectiveness in dysphagia rehabilitation.[28] Many of these maneuvers/exercises target laryngeal excursion or vocal fold adduction, which are critical biomechanical components in swallowing and phonation. Along with SE,[22,29] the Mendelsohn Maneuver (MM) and the Effortful Swallow (ES) are swallowing maneuvers that improve laryngeal excursion. In MM, patients are instructed to attempt to sustain the larynx in an elevated position while swallowing.[30] In ES, patients are instructed to "swallow hard" while squeezing the tongue in an upward and backward motion toward the soft palate[31,32] among other possible instructions, and can be performed with saliva[33] or other boluses.[34]

Evidence supports MM and ES as suitable maneuvers to improve laryngeal excursion.[35–38] Similarly, the Supraglottic Swallow (SS) and Super Supraglottic Swallow (SSS) maneuvers aim at glottal closure.[39,40] In the SS maneuver, patients are instructed to take a deep breath, hold the breath, swallow while holding the breath, and cough immediately after swallowing.[41–43] In the SSS maneuver, patients must follow the same steps as SS but also hold the breath with effort.[43] The effects of MM, ES, SS, and SSS on laryngeal biomechanics during phonation remain unknown, thus their clinical utility in voice rehabilitation has yet to be determined, especially in hypofunctional laryngeal pathology where laryngeal mobility could be compromised.[44,45]

The principles of Exercise Physiology (EP) and Motor Learning (ML), whose adoption represents a current trend in dysphagia rehabilitation,[46,47] have not been explored or discussed in relation to certain swallowing maneuvers/exercises (MM, ES, SS, and SSS). As a result, there is a lack of detailed clinical guidance on applying these EP and ML principles. ML principles relate to the optimal conditions for acquiring a new motor behavior, covering both the prepractice and practice phases of training, and strategies for the behavior's retention. The prepractice phase involves the clinician's preliminary guidance to the client, for example, explaining the purpose of each proposed exercise. Practice conditions include parameters such as amount, distribution, complexity, scheduling, and focus of attention, as well as the type and timing of feedback. Strategies for motor behavior retention include methods to assess performance improvements after the practice phase, as detailed in the comprehensive review by Maas et al. Parallelly, according to EP principles, applying the overload principle, increasing muscle strength, or endurance requires training programs that exceed the target muscle's ordinary capacities.

Application of EP and ML principles to swallowing rehabilitation has been mainly studied in lingual exercise. The evidence has demonstrated that following a progressive resistant isometric lingual exercise strength program, with a specific number of repetitions and frequency of practice, patients with dysphagia[48] and healthy older adults[49] can increase their lingual strength, with gains in their swallowing ability and muscle mass of intrinsic tongue muscles, which supports EP approach incorporation to therapeutic plans, although more research is needed about ML principles' incorporation into lingual exercise[50,51] and other swallowing rehabilitation techniques.

Within this context, the research question posed is: Do a set of swallowing maneuvers/exercises, practiced together with related vocal exercises, have the potential to impact phonatory biomechanics, thereby improving the vocal performance? This study is exclusively dedicated to the design and conceptual validation of a cross-therapy protocol for vocal rehabilitation, incorporating dysphagia therapy techniques proven to affect laryngeal excursion and vocal fold closure. The focus is specifically on hypofunctional laryngeal pathologies, which involve reduced vocal fold closure and diminished laryngeal excursion. These conditions are commonly seen in patients with hypophonia, where strengthening these functions can significantly improve vocal outcomes.

It is hypothesized that the design of a therapy protocol, which integrates swallowing maneuvers/exercises into voice rehabilitation, is an appropriate procedure to establish a cross-therapy strategy for voice and swallowing disorder rehabilitation and that this protocol can be valued positively by clinical experts. This protocol focuses on shared anatomical structures (larynx, hyoid bone, and adjacent musculature) and biomechanic components (glottal closure and laryngeal excursion), aiming to optimize their coordination during both phonation and swallowing.

Through its implementation, it is expected that patients gain greater laryngeal mechanism control, resulting in a notable improvement in voice production. The adoption of a cross-therapy protocol is anticipated to induce significant improvements in the acoustic and perceptual properties of the voice, including higher vocal intensity and greater pitch stability among individuals with voice disorders. The integration of traditional voice therapy exercises with specific swallowing maneuvers/exercises has been proven to facilitate substantial improvements in both the oral and pharyngeal phases of swallowing,[52] therefore, it is hypothesized that swallowing maneuvers/exercise practice could also assist voice rehabilitation. Equally, it is possible that individuals receiving cross-therapy may exhibit higher levels of compliance and engagement in their treatment, leading to more favorable clinical outcomes compared with conventional therapeutic methods for swallowing and voice disorders.

This study lays the groundwork for future inquiries, focusing on the development and validation of the protocol's content, through a conceptual and methodological approach anchored in existing literature and expert validation. The practical implementation and piloting of the protocol are not encompassed within this study's scope, thereby establishing a foundation for future research to assess its efficacy in clinical settings.

METHODS

Study design

A descriptive research design was adopted, focusing on the development and validation of a cross-therapy protocol for phonation rehabilitation using dysphagia rehabilitation techniques. This methodological approach facilitated the formulation of a comprehensive protocol that effectively addresses the interaction between swallowing and phonation. Expert judges were utilized for protocol validation, following established procedures to ensure rigor and clinical relevance.

German seminar

The German seminar methodology[53] was employed to enable a thorough exploration of perspectives in speech-language pathology, specifically in vocology, swallowing, dysphagia rehabilitation, and voice disorders. This method, deeply rooted in the German academic tradition, emphasizes active participation, critical thinking, and collaborative knowledge creation.[53] Five German seminar sessions were conducted, involving all authors of the present article, who are speech-language pathologists with expertise in the field of vocology, swallowing, and rehabilitation of dysphagia and dysphonia. In addition to their research experience, all authors have served roles in clinical care processes, encompassing assessment and intervention in these types of disorders. Their contribution to the development of the cross-therapy protocol reflects theoretical-methodological knowledge and direct practical experience in managing patients with swallowing and voice alterations, thus ensuring that the proposed protocol is grounded in a comprehensive understanding of clinical needs and best practices in the field. The seminar series allowed for in-depth discussions and knowledge exchange, ensuring a critical evaluation of the proposed protocol.

Protocol development phases

Phase 1: literature review and German seminar

In the initial phase, the literature review was not bound to a specific systematic review protocol, as the main goal was not to perform an exhaustive review per se but rather to use the literature as a resource to inform and enrich evidence-based discussions among experts. The selection of studies was guided by their thematic relevance, methodological rigor, and contemporary significance in areas such as swallowing and phonation physiology, as well as dysphagia rehabilitation exercises with potential applicability in phonation rehabilitation. Primary academic databases, including PubMed, Scopus, and Web of Science, were consulted, and narrative synthesis techniques were applied to consolidate and summarize relevant findings, allowing for thematic and conceptual integration that underpinned the discussion in the German seminar.

The German seminar was structured into sessions designed to last 90 minutes each, with participation from all authors of the present article, acknowledging their expertise in the field. The seminar methodology was based on principles of interdisciplinary knowledge exchange and collaborative analysis. Each session began with a thematic presentation by a designated expert, followed by a critical discussion period. Specific roles were assigned to participants, including facilitator, presenter, critic, and recorder, to promote dynamic and productive interaction. Detailed reports of each session documented key points, decisions, and areas of consensus or dissent.

In the first two sessions, the biomechanical components shared by swallowing and phonation were examined, highlighting the importance of vocal fold adduction, laryngeal excursion, and other shared mechanisms underlying both functions. This detailed analysis provided a foundation for identifying swallowing exercises with potential application in phonatory rehabilitation. The third session was dedicated to exploring the neuromotor relationship of voice and swallowing functions, focusing on how innervation and muscle coordination influence both capabilities. This discussion allowed for a deeper understanding of the involved neuromuscular dynamics, facilitating the selection of swallowing maneuvers that could benefit voice rehabilitation. Subsequently, the fourth session addressed the principles of EP applied to phonation and swallowing rehabilitation. This session emphasized how the principles of overload, specificity, and adaptation could be employed to design exercises that specifically improve swallowing and phonation functions, integrating the latest evidence to underpin the protocol's recommendations. Finally, the fifth session focused on conceptualizing the cross-therapy concept, defining its foundations, and outlining the scope of this integrative approach. The discussion on how cross-therapy, by combining techniques from both swallowing and phonation rehabilitation, offers a comprehensive framework to effectively address concurrent disorders, was highlighted.

To facilitate idea exchange and ongoing collaboration outside of in-person sessions, online collaborative tools such as Google Docs for joint document creation and editing, and communication platforms like Microsoft

Teams for real-time discussions and virtual meetings were used. These tools enabled smooth and accessible interaction among experts, ensuring broad participation and optimal utilization of their experience and knowledge in refining the proposed cross-therapy protocol.

Phase 2: protocol elaboration

This phase involved the procedural analysis of a variety of swallowing exercises, grounded in a methodology that included the review of existing protocols, evaluations of their efficacy based on scientific evidence, and consideration of their clinical applicability. To ensure a comprehensive evaluation, exercises were categorized not only by their impact on laryngeal biomechanics and glottal closure but also considering all biomechanical components relevant to phonation and swallowing. This included aspects such as neuromuscular coordination, specific structure strengthening, and respiratory function optimization in relation to voice and swallowing.

For exercise categorization, a classification system was developed to assess each exercise's contributions to the biomechanical processes of swallowing and phonation. Variables such as improvement in neuromuscular control, increased strength and endurance of involved muscles, and effectiveness in glottal closure and laryngeal excursion were considered. This process allowed for a logical and functional organization of exercises, facilitating their subsequent analysis and selection.

Initially, a pull of seven swallowing rehabilitation techniques were reviewed: SS, MM, Masako or tongue-hold maneuver, effortful swallowing, expiratory muscle strength training (EMST), SE, and lingual exercise. Of these techniques, three were discarded. Masako maneuver was not included into the protocol because its mean target is the improvement of pharyngeal contraction during swallowing.[54,55] Similarly, despite of the good evidence for EMST and lingual exercise in swallowing rehabilitation, these techniques were not directly related with improvement of laryngeal biomechanics. The main outcome of EMST is related with an improvement in maximum expiratory pressures in favor of airway protection[56] and the effects of lingual exercise are related with an enhancement of suprahyoid musculature activity and lingual pressure generation,[48,49,57,58] but without evidence of a direct link between this technique and laryngeal kinematics, for example, hyoid bone displacement. Also, although there are some positive effects of EMST on voice outcome,[15,16,21] this technique relies on a device, which is not always available in all clinical settings, which could prevent its actual applicability.

For each exercise selected definitively, detailed technical sheets were created, including a description of the procedure, specific therapeutic objectives, and evidence of effectiveness based on previous studies (background—Table 1). These technical sheets were designed to provide a clear and concise guide on how to implement each exercise within the protocol, including recommendations on frequency, duration, and intensity of practices.

The construction of the protocol was carried out through a detailed step-by-step process, considering the principles of ML and EP. It began by identifying the protocol's general objectives based on the needs identified in the literature review and German seminar phase. Subsequently, exercises were selected and grouped based on their contribution to these objectives, ensuring comprehensive coverage of identified key areas.

ML principles related to the acquisition and retention of motor skills, such as practice variability, attentional focus, and specific feedback, were integrated. EP principles were applied to adjust the load and intensity of exercises, promoting the development of strength and endurance in the involved muscular structures. Based on the technical sheets, a therapeutic itinerary was drafted, describing the optimal sequence and combination of exercises, as well as strategies for their progressive implementation based on the patient's skill level and improvements.

The proposed protocol was subjected to a feasibility evaluation by a preliminary group of clinicians, who provided feedback on its practical applicability and adjustment suggestions. This allowed for refining the protocol to ensure its clinical relevance and ease of implementation.

Phase 3: content validation

A panel of seven experts was formed, selected through inclusion criteria that ensured their deep knowledge and experience in vocology, swallowing, and the rehabilitation of dysphagia and dysphonia. The inclusion criteria required a minimum of 5 years of relevant experience in the field, significant academic contributions through publications in the area, and established professional recognition in these specialties. A 2-week period was assigned for this validation process.

A specific validation instrument was developed, designed to assess critical aspects of the protocol, such as its clinical relevance, theoretical coherence with the established conceptual framework, practical applicability in clinical settings, and clarity in the presentation of procedures.

The validation instrument consisted of several key components:

1. Evaluated categories:
   a. Biomechanical component: Evaluated the sufficiency, coherence, relevance, and clarity of the targeted biomechanical behaviors for rehabilitation.
   b. Exercise instruction: Assessed the clarity and relevance of the instructions provided for each exercise or maneuver.
   c. Pre practice: Examined the preparation activities to ensure they were sufficient and coherent with the Cross-Therapy approach.

d. Practice: Analyzed the sufficiency and relevance of the practice regimen, ensuring it aligned with ML principles.
e. Retention/Transfer measures: Considered the appropriateness and clarity of the measures used to evaluate the effectiveness of the therapy.

2. Validation instrument and instruction manual:
The instrument included detailed criteria for scoring each category on a scale of 1–3, with definitions provided for sufficiency, coherence, relevance, and clarity (Appendix 1). An instruction manual was created to guide the expert judges through the evaluation process, ensuring consistency and depth in their reviews.
3. Pilot testing:
The validation instrument and instruction manual were pilot-tested with a select group of experts to confirm usability and relevance. Feedback from this pilot test was used to refine the tool before broader implementation.
4. Evaluation process:
The intervention protocol, validation instrument, and instruction manual were sent to seven experts via email. Experts rated each protocol component and provided qualitative feedback. The collected data were consolidated using Microsoft Excel, and responses were weighted to identify areas for improvement. This iterative feedback and adjustment cycle spanned 6 weeks, allowing for continuous refinement of the protocol.
5. Feedback and iteration:

Expert feedback was instrumental in making necessary modifications to enhance the protocol's validity and potential efficacy. The iterative approach ensured that the final protocol balanced theoretical foundations with clinical practicality, reflecting the specialized knowledge of the field experts.

Two essential tables were incorporated into the validation process: one for the protocol rating instruction (Appendix 1), and another for the evaluation instrument used (Appendix 2). These tables were attached to the validation document to provide a clear and structured guide during the assessment.

The consolidation of the information collected was carried out using Microsoft Excel. The intervention protocol, the validation instrument, the corresponding instruction manual, and the background consolidated in the previous phase (Appendix 2), were sent to each of the seven experts via email, ensuring direct and effective communication. Similarly, the experts' responses and evaluations were received through this same channel, facilitating a coherent and centralized validation process.

Upon receipt of the evaluations, the responses were weighted, and the comments were considered to make the necessary modifications or adjustments to the protocol, as indicated in the evaluation by the expert judges. This feedback and adjustment cycle extended over 6 weeks in total, allowing for refined iteration and continuous improvement of the protocol, until a robust consensus on its validity and potential efficacy was reached. This iterative approach ensured that the final protocol reflected a balance between theory and clinical practice, supported by the experience and specialized knowledge of the experts in the field.

Data analysis and statistics

Phase 3 of the cross-therapy protocol validation study incorporated statistical analysis to ensure the reliability and validity of the validation instrument used. Two main statistical indicators were utilized: Cronbach's alpha for reliability and the Content Validity Coefficient (CVC) for validity. The calculations were performed using Python with the SciPy and Pandas libraries.

Reliability calculation: Cronbach's alpha

This calculation assesses the internal consistency of a measurement instrument, indicating the extent to which a set of items measures a single, unidimensional concept or dimension. Cronbach's alpha is expressed as

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{K}\sigma_{y_i}^2}{\sigma_x^2}\right) \tag{1}$$

where K is the total number of items in the instrument, $\sigma_{y_i}^2$ is the variance of each individual item, and σ_x^2 is the total variance of the summed scores of all items.

This coefficient ranges from 0 to 1, where higher values indicate greater internal consistency. A Cronbach's alpha value equal to or greater than 0.7 is generally considered acceptable for most research in social and health sciences, indicating adequate reliability of the instrument. This procedure allowed for the assessment of the consistency with which the instrument's items measured the quality and applicability of the cross-therapy protocol.

Content validity calculation: CVC

The CVC is used to assess the representativeness and relevance of an instrument's items in relation to the domain or construct it aims to measure. To calculate the CVC, experts are asked to rate each item of the instrument in terms of its relevance using a predefined scale. The CVC is calculated as the number of items rated as relevant by the experts divided by the total number of items, adjusted for the number of experts:

$$CVC = \frac{\sum_{i=1}^{N} relevance(i)}{N \times K} \tag{2}$$

where N is the number of experts, K is the total number of items, and $relevance(i)$ is the relevance rating for item i assigned by the experts.

In this study, the CVC was calculated for each item of the validation instrument. Items that achieved a CVC higher than a pre-established threshold (eg, 0.78) were considered highly relevant to the construct being measured, indicating good content validity of the instrument.

Ethical considerations

The study was conducted strictly adhering to the ethical principles established in scientific research. Approval was obtained from the ethics committee of the Corporación Universitaria Iberoamericana, and written informed consent was ensured from all participating experts. Measures were taken to ensure data confidentiality and manage potential conflicts of interest. Although the current focus is limited to the construction and validation of the protocol content, the structure of a potential future study to assess the protocol's effectiveness in a clinical setting is discussed. Considerations for participant selection and outcome measurement methods are contemplated.

RESULTS

During phase 1 of the study, the literature review and expert meetings were structured around specific themes, reflecting a thorough inquiry into the intersections and particulars of swallowing and phonation. The German seminars were organized into five thematic sessions, each focused on crucial aspects for the development of the cross-therapy protocol. The outcome of this phase was the background consolidation presented in Table 1.

In phase 2 of the study, the structure and content of the cross-therapy protocol aimed at phonation rehabilitation through swallowing rehabilitation techniques were consolidated. The culmination of this phase materialized in the development of a comprehensive protocol that amalgamates evidence-based therapeutic strategies, aiming to address the needs of patients with concurrent swallowing and voice disorders. The final validated protocol is presented in detail in Tables 2 and 3.

The validated protocol incorporates four key exercises and maneuvers designed specifically for the cross-rehabilitation of voice and swallowing disorders. These include the SS, MM, SE, and ES. Each exercise targets specific biomechanical components involved in phonation and swallowing, combining conventional instructions with cross-therapy approaches that apply principles of EP and ML.

The protocol was designed considering recommendations and adjustments suggested by an expert panel, ensuring its effectiveness in clinical practice. The structure, components, and application guidelines are detailed in Table 2, facilitating its implementation and future studies on its effectiveness in real treatment settings.

The protocol items, divided into five categories: biomechanical component, exercise instruction, pre practice, practice, and retention or transfer measures, received scores that reflected consensus on their appropriateness, consistency, relevance, and clarity. The following sections provide a discussion of each category.

Biomechanical component

The exercises target specific biomechanical aspects such as vocal fold adduction, laryngeal excursion, and upper esophageal sphincter opening. These components were selected based on their relevance to both phonation and swallowing functions, ensuring that the protocol addresses critical areas of dysfunction in patients with concurrent disorders.

Exercise instruction

Each exercise was accompanied by detailed conventional instructions to ensure proper execution. For example, the SS involves taking a deep breath, holding it, swallowing, and then coughing immediately. These instructions were validated for clarity and ease of understanding by the expert panel, ensuring that patients could perform them correctly with minimal supervision.

Pre practice

This category includes preparatory activities designed to familiarize patients with the exercises and enhance their effectiveness. For instance, patients are instructed on the sensations and movements involved in each exercise, using visual aids and analogies to facilitate comprehension. The prepractice phase helps patients build the necessary skills and confidence to perform the exercises effectively.

Practice

The practice regimen involves structured and repetitive execution of the exercises, adhering to principles of EP and ML. Patients will attend four weekly sessions and perform the exercises twice daily on nonsession days. Each exercise will be practiced at least 20 times per session, integrating phonatory tasks to enhance glottal closure and vocal quality.

Retention or transfer measures

The protocol includes specific metrics to assess improvements in both phonation and swallowing functions. For example, measures for phonation include grade of breathiness, maximum phonation time, and vocal loudness, while measures for swallowing include voluntary control of glottic closure and laryngeal excursion during swallowing. These metrics help evaluate the long-term effectiveness and transferability of the exercises to real-life scenarios.

The expert panel's validation of these categories confirms the protocol's appropriateness and applicability in clinical practice, providing a robust framework for the rehabilitation of patients with concurrent swallowing and voice disorders.

Validation of the cross-therapy protocol

The expert panel's evaluation of the cross-therapy protocol showed remarkable acceptance, with an average CVC of

TABLE 1.
Therapy Protocol's Theoretical and Empirical Background

Maneuver/ Exercise	Exercise physiology principles*	Motor learning principles: Structure of practice	Motor learning principles: Feedback timing and frequency	Motor learning principles: Type of feedback	Suggested vocal tasks that boost the transference of the effect of the maneuver/ exercise to phonatory physiology
Supraglottic swallow (SS)	Overload: A way to increase the load during the SS practice is to include the execution of the maneuver's super-supraglottic (SSS) variance, in which extra effort is required during the breath-holding phase. Martin et al[40] demonstrated that vocal fold adduction is enhanced during both SS and SSS. A practical way to control the exerted effort by the patient during the breath-holding phase of the maneuver could be a Likert scale, like in the Lee-Silverman Voice Treatment, in which a scale of 1–10 is helpful to the patient to know the intended effort during a "good" voice production.[59] Specificity: SS maneuver is based on the practice of swallowing itself, specifically the timing of the laryngeal vestibule closure and the transit of the bolus through the pharynx. Although the effects of	Amount and distribution: These conditions can be addressed according to the determinants of dose exercise in dysphagia intervention proposed by[61]: *Intensity*: The patient is asked to "swallow with effort" in SS[17] and must hold their breath, bearing down hard in SSS.[62] Originally, the amount of effort is not measured by the clinician. *Repetitions*: Sets of 10 or 20 repetitions[17,30] *Frequency*: Two or three sets per day, 6 or 7 d per week.[17,30] *Duration*: 8 to 12 wk.[17,30] Variability and complexity: These conditions can be addressed by varying the amount of effort exerted by the patient during the breath-holding phase of the maneuver and the execution of the SS with or without boluses.[39] studied the SS performance with 4-ML liquid boluses, and it is known that the more viscous the bolus, the greater the swallowing effort.[46] Schedule: The SS is commonly practiced in blocks of "n" repetitions followed by blocks of other maneuvers.[17,63] This exercise format could be appropriate for the beginning of the	The work of Imada et al[39] suggests that high-frequency and immediate feedback are helpful, at least at the beginning of the learning of the maneuver for those people that cannot master the SS spontaneously.	Imada et al[39] found that the subjects who trained the SS with the video endoscopy (knowledge of performance) mastered the maneuver in fewer days than participants who had no access to any kind of knowledge. There are no comparative studies of the two types of feedback (knowledge of performance vs knowledge of results) in the SS acquisition and retention process.	The SS could be combined with phonatory tasks in which the patient must hold the breath before voice production or phonate after volitional coughing because glottal closure is fostered in both conditions. Suggested vocal tasks are described by.[64,65] —Cough and then make a sustained phonation. —Take air in, hold it, making a minor apnea, and then make a vocal production of progressive complexity (short and sustained phonation of vowels, syllables like /ka/, /ke/, /ko/, /ga/, /ge/, /go/) In literature, the combination of swallowing and nonswallowing exercises (phonatory exercises) in dysphagia rehabilitation programs is considered a way to address neuroplastic principles of specificity and transference.[17]

TABLE 1 (*Continued*)

Maneuver/ Exercise	Exercise physiology principles*	Motor learning principles: Structure of practice	Motor learning principles: Feedback timing and frequency	Motor learning principles: Type of feedback	Suggested vocal tasks that boost the transference of the effect of the maneuver/ exercise to phonatory physiology
	SS (or SSS) on phonation are unknown, a way to address its vocal specificity could be through the combined practice of this maneuver with phonatory tasks that foster vocal fold adduction, like the one studied by Fujimaki et al.[60]	intervention process to promote its correct acquisition. For example, Imada et al[39] found that after 30 consecutive repetitions of the SS, participants who could not master the maneuver spontaneously could master it accurately. A less-structured practice (not in blocks) is recommended to boost motor learning, which could be reached by randomly varying the effort and the bolus in every repetition. Attentional focus: External focus promotes learning. Feedback through video endoscopy is helpful in the acquisition of SS.[39] Also, in patients with dysphagia, the focus could be directed to the effects of the SS on the airway protection (reflex cough is present/absent during the SS with boluses). During vocal task practice, the focus must be shifted to a less breathy or stronger voice.			
Mendelsohn maneuver (MM)	Overload: This maneuver is an isometric exercise that allows the calculation of the maximal repetition by measuring the extent of time the laryngeal elevation can be sustained during a sallow. According to	Amount and distribution: *Intensity*: Muscular effort is required to raise the larynx and hold this position during the maneuver.[30] *Repetitions*: Literature suggests an extended practice to reach results. Although the exercise regimen varies among authors,[36,66,67] it is recommended to practice the	At the beginning of the intervention, there could be convenient high-frequency and immediate feedback. However, low-frequency and delayed	Literature about the MM describes the use of knowledge of performance to monitor the realization of the maneuver. However, this knowledge mainly has a prescriptive and not descriptive purpose. The knowledge of performance is delivered by superficial electromyography or	The MM can be combined with the production of ascendent glissandos and sustained phonations in a higher pitch than habitual. In these vocal tasks, the laryngeal biomechanics are similar to the MM execution. When vocal folds are tensioned, like in ascendent glissandos, the

TABLE 1 (*Continued*)

Maneuver/ Exercise	Exercise physiology principles*	Motor learning principles: Structure of practice	Motor learning principles: Feedback timing and frequency	Motor learning principles: Type of feedback	Suggested vocal tasks that boost the transference of the effect of the maneuver/ exercise to phonatory physiology
	the author, the time of maximal laryngeal elevation could be 2,[36] 3–4,[66] or even 6 s.[67] During the training period, the MM must be practiced in one set of ten repetitions in 5 min,[67] 30 repetitions in 45 min,[66] or 20 repetitions in 45 min,[17] three times per day.[17,67] According to Burkhead et al,[46] the MM increases the effort and neuromuscular activation because the patient is instructed to hold the larynx in its highest position for a determined period. The clinician could manipulate this time to achieve the overload principle during the treatment. Specificity: The MM directly trains laryngeal elevation, making the patient more conscious about this mechanism during swallowing. Laryngeal elevation is also needed for voice production.[2] The vocal specificity of the MM could be enhanced by its combination with	MM in a single set of 20–30 repetitions three times per day. *Frequency*: Practice should be spaced throughout the day to promote long-term learning. Taking it into account, the daily number of repetitions is between 60 and 90 and weekly between 420 and 540 repetitions.[36,66,67] *Duration*: Beyond 2 wk.[36,66,67] Variability and complexity: Although there is a lack of literature about applying this principle in the MM, it should be considered practice the MM varying the intended time of maximal laryngeal elevation in every repetition, the bolus presence, and the bolus size and consistency. Equally, the negative practice strategy could be considered to highlight the sensorial differences between a correct and incorrect maneuver execution. Schedule: To improve long-term learning, the MM should be practiced in combination with the other exercises/ maneuvers, especially those that also target laryngeal elevation. The literature supports this recommendation because the MM is more effective in combination than isolated.[67]	feedback are ideal in more advanced stages of intervention. Research is needed for more specific recommenda-tions about feedback frequency and timing during MM execution.	ultrasonography.[70,71] Also, it is essential that the clinician cues the patient about the intended and observable muscular contraction over the treatment session.[36,66,72]	area of glottal vibration is reduced.[73] Neck muscles support hyoid bone and larynx elevation, an essential mechanism for vocal pitch elevation.[74]

TABLE 1 (*Continued*)

Maneuver/ Exercise	Exercise physiology principles*	Motor learning principles			Suggested vocal tasks that boost the transference of the effect of the maneuver/ exercise to phonatory physiology
		Structure of practice	Feedback timing and frequency	Type of feedback	
	vocal tasks that promote laryngeal elevation, like pitch elevation.	Attentional focus: Most articles suggest an internal attentional focus since the patient must focus his/her attention on the larynx movement or the musculature.[66] As motor learning principles recommend, a possible alternative to focusing attention on an external cue could be larynx palpation or monitoring muscular activity by biofeedback devices.[68,69] Equally, during vocal task practice, focus must pose into a higher vocal pitch.			
Shaker exercise (SE)	Overload: The SE challenges neck and suprahyoid muscles during the head liftings that compose the isometric (IM) and isokinetic (IK) components of the exercise; these muscles must work against gravity because of the supine position that the patient must adopt during the exercise.[46] Specificity: The SE improves laryngeal excursion[12,22,29,75] and, like the MM, can be combined with specific vocal tasks to enhance its vocal specificity. In fact, explained as a	Amount and distribution: *Intensity*: The patient must hold the head lift for 1 min in the IM component. In the IK component, the patient must complete 30 sequential repetitions of a nonsustained head lift.[22,29] However, a gradual increment of the demand (time of head lifting in the IM component and number of repetitions in the IK component) is recommended.[75] *Repetitions*: Every SE execution comprises three IM contractions spaced by one resting minute between each contraction. After this, the patient must do 30 sequential IK contractions.[22,29] *Frequency*: Daily, one repetition of the exercise three times per day.[22,29]	Easterling et al[75] found that 100% and 50% of the participants accurately attained the IK and the IM components, respectively, as originally demanded by the exercise regimen, by delivering a weekly supervision session, which partially supports low-frequency feedback. It is expected that because of the complexity of the	Verbal cueing is described during the SE execution. It consists of asking the patient to lift her/his head in such a way that he/she can see his/her toes directly and make this without separating the shoulders from the support base while lying in the supine position. Because of the complexity of the body's accommodation during the exercise, performance knowledge is required at the beginning of the practice for the correct execution of the exercise. Once a good execution is obtained, the feedback type could be changed to the knowledge of results, boosting patient body awareness, who must identify why the execution is	Recommendations as was suggested to the MM.

TABLE 1 (*Continued*)

Maneuver/ Exercise	Exercise physiology principles*	Motor learning principles: Structure of practice	Motor learning principles: Feedback timing and frequency	Motor learning principles: Type of feedback	Suggested vocal tasks that boost the transference of the effect of the maneuver/ exercise to phonatory physiology
	consequence of extrinsic laryngeal musculature strengthening, some studies have found that SE per se has beneficial effects on vocal physiology.[13]	*Duration*: 6 wk.[22,29] Variability and complexity: Schedule: The original exercise format is entirely blocked, which is convenient for learning the exercise. However, the SE could be combined with other exercises, such as the MM, and its practice simultaneously or sequentially with compatible vocal tasks could be convenient to foster its randomized and complex practice. Attentional focus: In the SE, external focus is directed to the result of the required body accommodation. The patient must see his/her toes. If vocal tasks are practiced simultaneously or sequentially with the exercise, the patient must focus on reaching a higher pitch.	body accommodation during the exercise, immediate feedback is necessary, at least at the beginning of the intervention.	incorrect until it reaches a successful execution.	
Effortful swallow (ES)	Overload: The ES is considered both a strength training task and a skill training task. As a strength training task, it is considered that ES execution demands greater muscle activation than a normal swallow.[46,76] Specificity: A repeated execution of ES drives improvements in	Amount and distribution: *Intensity*: The patient is asked to "swallow hard" while squeezing the tongue in an upward and backward motion toward the soft palate.[31,32,77] *Repetitions*: Commonly, the ES is practiced as part of rehabilitation programs that include other exercises/ maneuvers. In such programs, the ES is executed in sets of 10–20 repetitions.[17,63] *Frequency*: daily, three times	The clinician must remember to the patient swallow hard before every ES execution while the patient learns the exercise. In clinical practice, the clinician could train the patient recognizing how feel and effortful and a noneffortful	Knowledge of results can be achieved by surface electromyography calculating the swallow effort ratio, a comparison of the peak amplitude of an effortful- and a noneffortful swallow.[78]	Recommendations as was suggested to the MM.

TABLE 1 (*Continued*)

Maneuver/ Exercise	Exercise physiology principles*	Motor learning principles: Structure of practice	Motor learning principles: Feedback timing and frequency	Motor learning principles: Type of feedback	Suggested vocal tasks that boost the transference of the effect of the maneuver/ exercise to phonatory physiology
	swallowing physiology[76] and, between them, greater activation of submental muscles,[37,69] which is related to laryngeal excursion during swallowing and phonation. Like the SE and MM, the ES vocal specificity can be enhanced with its combined execution with specific vocal tasks that target some of its physiological effects, such as laryngeal elevation.	per day.[17] *Duration*: 8 wk.[17] Variability and complexity: This can be manipulated by varying the grade of effort and the characteristics of the bolus while ES is executed. Schedule: Combined with other swallowing and vocal exercises targeting laryngeal excursion. Attentional focus: In patients with dysphagia, attention must focus on improvements in pharyngeal residue sensation, laryngeal elevation during swallowing, and a higher pitch during phonation.	swallow and practice them alternatively until the patient can make a continuous reliable execution of the ES. Also is useful ask to the patient to swallow as if he/she was swallowing "hard meals" as stale bread. As was discussed in the previous maneuvers/ exercise, some grade of immediate and high-frequency feedback is needed at the beginning at the intervention but a progressive fading of this support is recommended according to motor learning theory.		

* Principles of adaptation, maintenance, and reversibility are not addressed because there needs to be more evidence to provide advice about these principles.

TABLE 2.
Validated Protocol

Exercise or Maneuver	Target biomechanical component		Conventional instruction to perform the exercise or maneuver	Cross-therapy approach applying principles of exercise physiology and motor learning			
				The patient attends 4 weekly sessions for 4 wk. On days when sessions are not attended, the same exercises should be performed twice daily. On session days, an additional practice session at home is required. Each maneuver/exercise and its corresponding phonatory task are practised a minimum of 20 times during each session. The number of sessions and their scheduling follow established programs for voice disorders that adhere to the principles of motor learning.[59] New speech therapy intervention programs with this dosage have been shown to be effective.[79] The minimum number of repetitions of each swallowing maneuver/exercise was established based on studies where these have been incorporated as part of treatment programs for dysphagia.[36,63,66,67,80]			
				Pre practice	Practice	Retention/Transfer measures (Improvements in any of the following parameters must be verified)	
	Phonation	Swallowing				Phonation	Swallowing
Supraglottic swallow (SS)	Vocal fold adduction[40] and laryngeal ex-cursion.[41]	Vocal fold adduction[40] and laryngeal excursion.[41]	1. Take a deep breath. 2. Hold the breath. 3. Swallow while you hold the breath. 4. Cough immediately after swallowing.[41–43]	1. The patient should be informed that the objective of this maneuver is to achieve a voice without air escape by improving the approximation of the vocal folds. 2. The clinician should demonstrate a desirable vocal quality (without air leakage) and an undesirable vocal quality (with air leak) so that the patient recognizes the voice to reach for and the one to avoid, respectively. 3. The clinician will model the incorporation of the SS by explaining its	Each SS (n = 20) will be preceded by the performance of a phonatory task aimed at promoting glottal closure (n = 20). Consider the following indications for the practice: 1. Encourage deep inspiration and breath- holding by instructing the patient to "imagine preparing to go underwater, so take a deep breath before diving and hold it all the time while submerged."2. Encourage breath-holding during swallowing by instructing the patient to ensure that	1. Grade of breathiness/breathy voice. 2. Maximum phonation time. 3. Loudness of the voice (or if you have a sound meter, intensity in dB). 4. Laryngeal excursion during phonation assessed by videofluoroscopy.[2]	1. Voluntary control of glottic closure verified by laryngoscopy when performing a SS.[39] 2. Frequency of cough events during oral intake with and without the maneuver, in patients with concomitant dysphagia. 3. Laryngeal excursion during swallowing assessed through videofluoro-scopy.[41]

TABLE 2 (*Continued*)

		effect on vocal fold closure. They can use photographs, models, or figures of the larynx. 4. The clinician will model each phonatory task and the patient must notice what happens to the vocal folds when phonating in this way. They can use photographs, models, or figures of the larynx.	the mouth remains closed throughout each execution of the SS (opening the mouth increases the likelihood of air escaping, leading to the loss of the apnea effect). To do this, the closure of the mouth can be monitored by having the patient to observe him/herself in a mirror or by the therapist asking the patient to indicate whether the mouth is open or not in each execution. 3. The clinician should guide the patient to gradually increase the effort in holding air during the SSS. A Visual Analog Scale can be used, where 1 represents minimal effort and 10 is the maximum effort. The patient and clinician should explore various levels of effort along this scale during each practice session to become familiar with the perceived effort in each level. 4. Provide instructions to help the patient explore the sensation at each level of effort. For instance, “while	

TABLE 2 (*Continued*)

holding your breath, force yourself as if you were going to lift something heavy or like when you go to the bathroom." Examples can be given of objects with different weights that go, "Imagine you are going to lift" to help the patient when performing the different levels of effort.

5. Once the patient is acquainted with all levels of effort, the clinician should emphasize levels 5–8, representing the maximum possible effort.

6. After the patient can discern the degree of effort applied in the maneuver, the SS will be performed varying the levels of effort in each performance, focusing on effort levels between 5 and 8.

7. After each SS, the patient must randomly practise one of the following phonatory tasks, performing apnea with the same level of effort applied in the preceding SS:

—Inhale, hold breath, and then

TABLE 2 (Continued)

					cough with diaphragmatic support. —Cough followed by releasing a vowel. —Inhale, hold breath with a brief apnea, and then produce sounds of varying complexity (short vowels, sustained vowels, and syllables like /ka/, /ke/, /ko/, /ga/, /ge/, /go/). 8. During phonatory tasks, the clinician must ensure that the voice does not exhibit air leakage. For sustained phonation of vowels, the clinician may progressively establish more challenging objectives for the loudness and duration of each production, considering the patient's maximum phonation time prior to treatment initiation.		
Mendelsohn maneuver (MM)	Laryngeal ex-cursion.[30]	Laryngeal excursion and opening of the upper esophageal sphincter.[81]	1. The patient is instructed to swallow saliva, while placing his fingers on the thyroid cartilage, aiding in perceiving the rise of the larynx, and asking him/her, “do you feel it moving?” “Do you feel it rise?”2. Once	1. The patient should be instructed that the objective of this maneuver is to enhance the capacity to produce diverse vocal tones by focusing on laryngeal elevation, thereby facilitating voice improvement. Explanation will be	Each incorporation of the MM ($n = 20$) will be preceded by the performance of a phonatory task in which the patient must vary the vocal pitch ($n = 20$). Consider the following indications for the practice:	1. Ability to raise vocal pitch (vocal range). 2. Grade of breathiness/breathy voice. 3. Maximum phonation time. 4. Electromyographic activity in the suprahyoid muscles during phonation.	1. Maximum voluntary laryngeal elevation time. 2. Electromyographic activity of the suprahyoid muscles during swallowing.[68] 2. Laryngeal excursion during

TABLE 2 (*Continued*)

		the patient identifies the ascending position, is instructed to maintain maximum elevation for several seconds after swallowing. For instance, this can be achieved by forcefully contracting the tongue against the palate to prevent laryngeal descent. 3. The therapist can assist this maneuver by gently holding the thyroid cartilage with the thumb and index finger when maximum elevation during swallowing. However, this assistance is provided only as needed because the patient must execute the maneuver independently.	provided on how altering vocal tone during speech, for instance, to communicate different emotions or intentions with the voice, involving variations in intonation, and how dysphonia limits this ability. 2. The clinician will illustrate the distinction between a sustained phonation and an ascending glissando by demonstrating each using the vowel /i/, enabling the patient aware of the differences between one and the other. Visual aids, such as imagining a horizontal straight line for sustained phonation and an ascending line for ascending glissando, may be used. 3. The clinician will demonstrate the incorporation of the MM showing to the patient the method of maintaining laryngeal elevation.	1. The patient will practice MM under the guidance of the clinician, following conventional instructions for executing the maneuver. 2. The clinician will provide guidance to the patient using tactile, visual, and verbal instructions. —Tactile: This may involve palpation of the own larynx's displacement movement or the therapist's larynx movement.[66] —Visual: The maneuver can be demonstrated with the support of visual cues observed on a computer (eg, electromyography curves) or by monitoring laryngeal movement using a mirror. —Verbal: The clinician may give verbal instructions such as: "when you swallow and feel something rise, maintain your Adam's apple elevated, do not let your Adam's apple fall. Use your muscles to keep it elevated for several	5. Laryngeal excursion during phonation assessed by videofluoroscopy.[2]	swallowing assessed through videofluoro-scopy.[68]

TABLE 2 (*Continued*)

seconds". "As you swallow, squeeze hard with all your muscles."

3. The clinician will ensure that the patient can consistently perform the maneuver and will prompt the patient to indicate each instance he or she successfully maintains the larynx elevated for as long as he or she maintains the larynx position, for example, by raising one hand and keeping it held as long as he or she keeps the larynx up.

4. During each practice set, the clinician will instruct the patient to perform the MM with varying durations of laryngeal elevation: short (2 s), medium (3–4 s), and long (≥6 s),[36,66,67] randomly selected for each series of MM incorporation.

5. Following each incorporation of the MM, the clinician will instruct the patient to perform phonatory tasks randomly throughout each

TABLE 2 (*Continued*)

					series of the maneuver. Below are phonatory tasks arranged from least to greatest complexity: —Sustain a phonation with /i/ at a comfortable pitch and then in a higher pitch (*) —Sustain a phonation with /i/ in a comfortable pitch and then make other two sustained phonations in two higher pitches (*) —Sustain a phonation with /i/ in a comfortable pitch and then make other three sustained phonations in three higher pitches —Make an ascending glissando with /i/ —Make an ascending and then descending glissando with /i/ *Sustained phonation in a higher pitch should last the same duration or longer than the laryngeal elevation time achieved in the immediately preceding MM.		
Shaker exercise (SE)	Laryngeal ex-cursion.[82]	Opening of the upper esophageal sphincter and	1. Lie on your back (on the floor or on a mattress or firm	In certain studies, patients have been shown an	The therapy begins with the isometric component of the	1. Ability to raise vocal pitch (vocal range).	1. Frequency of sensation of pharyngeal

TABLE 2 (*Continued*)

		laryngeal excursion.[22,75]	surface). 2. Keep your shoulders flat on the floor. Do not raise your shoulders. 3. Bend your neck forward so that your chin is closer to your chest. 4. Try to see your toes. 5. Keep the position as instructed by the professional (isometric and isokinetic). Isometric component: The patient must maintain the head elevation three times for 1 min each, with a rest between attempts also of 1 min. Isokinetic component: The patient performs 30 consecutive nonsustained head raisings.	instructional video demonstrating the exercise before beginning systematic practice.[75]	ES, involving three sustained head raising, followed by the practice of the isokinetic component (n = 30). Upon completion of the entire SE, the patient will perform ascending glissandos with /i/ to the highest tone achieved in each attempt (n = 30). As therapy progresses, the clinician may request the patient to produce increasingly longer maximum phonation time at the highest tone reached and varying the degree of pitch elevation randomly.	2. Grade of breathiness/breathy voice. 3. Maximum phonation time. 4. Electromyographic activity in the suprahyoid muscles during phonation. 5. Laryngeal excursion during phonation assessed by videofluoroscopy.[2]	residue during swallowing in patients with concomitant dysphagia. 2. Electromyographic activity of the suprahyoid musculature during swallowing.[83] 3. Laryngeal excursion during swallowing assessed by videofluoroscopy.[29]
Effortful swallowing (ES)	Laryngeal excursion.[38,84]	Enhance pharyngeal contraction, laryngeal elevation, and lingual pressure generation during swallowing.[76]	1. Rest your tongue against the roof of your mouth. 2. Swallow "hard," with effort. 3. Imagine you are passing a golf ball.[17]	Implement steps 1 and 2 of prepractice for MM, demonstrating to the patient the effect of ES on laryngeal elevation and its correlation with improved vocal production. The clinician will demonstrate the ES by showing to the patient the movement of the	Practice ES should be preceded by a phonatory task in which the patient varies the vocal pitch. Consider the following guidelines for the practice: 1. The patient will practice ES under guidance of the clinician, adhering to conventional instruction for	1. Ability to raise vocal pitch (vocal range). 2. Maximum phonation time. 3. Electromyographic activity of the suprahyoid muscles during phonation. 4. Laryngeal excursion during phonation assessed by videofluoroscopy.[2]	1. Electromyographic activity of the suprahyoid musculature during swallowing.[85] 2. Laryngeal excursion during swallowing assessed through videofluoroscopy.[37]

TABLE 2 (*Continued*)

larynx during swallowing and how strengthening it can result in a more vigorous movement.	executing the maneuver. 2. Following each incorporation of the ES, the clinician will prompt the patient to perform phonatory tasks involving random changes in vocal pitch during each trial throughout the practice series (the same phonatory tasks indicated for the MM apply). 3. Within each series, the duration of each sustained phonation and the level of loudness may also be randomly varied.

TABLE 3.
Scores Awarded by Expert Judges

		Item		Judges 1	2	3	4	5	6	7	$\sum xi$	Mx	CVCi	Pei	CVCtc	Variance
Exercise 1: supraglottic swallowing (SSG)		Biomechanical behavior	Sufficiency	2	3	3	3	3	3	2	19	2.7	0.9	0.0	0.9	0.2
			Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	3	3	3	3	3	3	2	20	2.9	1.0	0.0	1.0	0.1
			Clarity	2	3	3	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
		Original instruction	Sufficiency	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
	Cross-therapy approach	Pre practice	Sufficiency	3	3	3	3	2	3	3	20	2.9	1.0	0.0	1.0	0.1
			Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	3	3	3	3	2	3	3	20	2.9	1.0	0.0	1.0	0.1
		Practice	Sufficiency	3	3	3	3	2	3	3	20	2.9	1.0	0.0	1.0	0.1
			Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	2	3	3	3	2	3	3	19	2.7	0.9	0.0	0.9	0.2
		Measures retention/transfer	Sufficiency	3	3	3	3	3	3	2	20	2.9	1.0	0.0	1.0	0.1
			Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
Exercise 2: Mendelsohn maneuver (MM)		Biomechanical behavior	Sufficiency	2	3	3	3	3	3	2	19	2.7	0.9	0.0	0.9	0.2
			Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
		Original instruction	Sufficiency	3	3	3	3	3	2	3	20	2.9	1.0	0.0	1.0	0.1
			Coherence	2	3	3	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
			Relevance	3	3	3	3	3	2	3	20	2.9	1.0	0.0	1.0	0.1
			Clarity	3	3	3	3	3	2	3	20	2.9	1.0	0.0	1.0	0.1
	Cross-therapy approach	Pre practice	Sufficiency	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	3	3	3	3	3	2	3	20	2.9	1.0	0.0	1.0	0.1
		Practice	Sufficiency	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	3	3	3	3	3	2	3	20	2.9	1.0	0.0	1.0	0.1
		Measures retention/transfer	Sufficiency	2	3	3	3	2	3	2	18	2.6	0.9	0.0	0.9	0.2
			Coherence	2	3	3	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	2	3	3	3	2	2	3	18	2.6	0.9	0.0	0.9	0.2
			Sufficiency	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0

TABLE 3 (*Continued*)

		Item		Judges 1	2	3	4	5	6	7	∑xi	Mx	CVCi	Pei	CVCtc	Variance
Exercise 3: shaker exercise (ES)		Biomechanical behavior	Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
		Original instruction	Sufficiency	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Coherence	3	3	3	3	3	2	3	20	2.9	1.0	0.0	1.0	0.1
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	3	3	3	3	3	2	3	20	2.9	1.0	0.0	1.0	0.1
	Cross-therapy approach	Pre practice	Sufficiency	3	3	2	3	2	3	3	19	2.7	0.9	0.0	0.9	0.2
			Coherence	3	3	2	3	2	3	3	19	2.7	0.9	0.0	0.9	0.2
			Relevance	3	3	2	3	2	3	3	19	2.7	0.9	0.0	0.9	0.2
			Clarity	3	3	2	3	3	2	3	19	2.7	0.9	0.0	0.9	0.2
		Practice	Sufficiency	3	3	2	3	2	3	3	19	2.7	0.9	0.0	0.9	0.2
			Coherence	3	3	2	3	2	3	3	19	2.7	0.9	0.0	0.9	0.2
			Relevance	3	3	2	3	2	3	3	19	2.7	0.9	0.0	0.9	0.2
			Clarity	3	3	2	3	2	2	3	18	2.6	0.9	0.0	0.9	0.2
		Measures retention/transfer	Sufficiency	3	2	2	2	2	3	2	16	2.3	0.8	0.0	0.8	0.2
			Coherence	3	3	2	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
			Relevance	3	3	2	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
			Clarity	3	3	2	2	2	3	3	18	2.6	0.9	0.0	0.9	0.2
Exercise 4: forced swallowing (fs)		Biomechanical behavior	Sufficiency	3	3	3	3	3	3	2	20	2.9	1.0	0.0	1.0	0.1
			Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	2	3	3	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
		Original instruction	Sufficiency	2	3	3	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
			Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	2	3	3	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
			Clarity	2	3	3	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
	Cross-therapy approach	Pre practice	Sufficiency	2	3	3	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
			Coherence	2	3	3	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
			Relevance	2	3	3	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
			Clarity	2	3	3	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
		Practice	Sufficiency	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	2	3	3	3	3	3	3	20	2.9	1.0	0.0	1.0	0.1
		Measures retention/transfer	Sufficiency	2	3	3	2	3	3	2	18	2.6	0.9	0.0	0.9	0.2
			Coherence	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Relevance	3	3	3	3	3	3	3	21	3.0	1.0	0.0	1.0	0.0
			Clarity	2	3	3	2	3	3	3	19	2.7	0.9	0.0	0.9	0.2
		Total		221	239	228	236	225	230	232						

0.95, indicating high validity and relevance of the protocol in integrating swallowing maneuvers for voice rehabilitation. The protocol items, divided into the categories of biomechanical component, exercise instruction, pre practice, practice, and retention or transfer measures, received scores that reflected consensus on their appropriateness, consistency, relevance, and clarity.

Biomechanical component

The evaluation highlighted the sufficiency, coherence, relevance, and clarity of the biomechanical targets addressed by each exercise. Experts confirmed that the selected biomechanical behaviors were critical for both swallowing and phonation rehabilitation, ensuring that the protocol effectively targets key physiological functions.

Exercise instruction

Instructions for each exercise were assessed for clarity and relevance. The panel found that the instructions were generally clear, concise, and easy to follow, ensuring that patients could perform the exercises correctly. However, minor adjustments were made to enhance the precision of the instructions based on expert feedback.

Pre practice

The prepractice phase was evaluated for its role in preparing patients for the main exercises. Experts agreed that the prepractice activities were sufficient and coherent with the objectives of Cross-Therapy, providing a solid foundation for effective practice.

Practice

The practice regimen was scrutinized for its sufficiency, coherence, and relevance. The panel endorsed the structured and repetitive nature of the practice sessions, emphasizing their alignment with ML principles. This approach was deemed effective in reinforcing the targeted skills through consistent and varied practice.

Retention/transfer measures

Two items related to the retention or transfer measures for the SE received slightly lower scores (between 0.70 and 0.80). These scores were attributed to errors in wording, which were subsequently corrected to improve clarity and accuracy. The adjusted measures now reflect better the intended outcomes and facilitate more accurate assessment of the protocol's effectiveness.

The comprehensive validation process, involving detailed feedback and iterative refinements, ensured that the final protocol is both theoretically sound and practically applicable. This robust consensus among the expert panel highlights the protocol's potential efficacy in clinical settings, providing a balanced integration of theory and practice.

Reliability statistical analysis

Statistical analysis using Cronbach's alpha yielded a value of 0.798 for the validation tool, demonstrating acceptable validity and confirming the internal consistency of the protocol developed. This result underlines the correlation and cohesion between the items evaluated, reinforcing the reliability of the protocol for its application in clinical contexts.

Qualitative changes and adjustments to the protocol

Five of the seven experts consulted provided feedback on the proposed protocol. Their comments covered several issues: (a) the inclusion of electromyography measurements as potential retention measures for all proposed swallowing exercises/maneuvers; (b) the inclusion of laryngeal excursion measurements as a retention measure for both phonation and swallowing, not just swallowing; (c) the addition of an explanatory video for the prepractice of SS to illustrate its effect on vocal cord closure, replacing the original photos and drawings; (d) standardization of the measurements of effort perceived by patients during the breath-holding phase of SS, equating these to weight values in kilograms instead of the Visual Analog Effort Scale originally proposed; (e) for the SE, the inclusion of both isokinetic and isometric components was suggested, not only the isokinetic component originally proposed; (f) finally, for the effortful swallowing maneuver, it was recommended to include the maneuver with head resistance during its execution.

With regard to these proposed amendments, comments "a," "b," "c," and "e" have been taken into account. Comment "d" has not been considered as, based on EP, the aim is not for all patients to perform or achieve the same effort values during the maneuver. Instead, the demands are adjusted according to the initial effort achieved by each patient at the start of therapy according to EP. Furthermore, in protocols with proven efficacy, such as the Lee-Silverman Voice Treatment (LSVT), effort during the intervention has been measured and controlled using a subjective scale similar to the proposed Visual Analog Scale.[59] On the other hand, the inclusion of the head resistance variation of effortful swallowing was rejected because it has not been studied and it is not known whether its performance improves the effect of the maneuver, as suggested by the expert, although it is a variation of the maneuver widely used by clinicians.

DISCUSSION

This research presents a cross-therapy protocol in the field of voice and swallowing rehabilitation. Drawing on EP and ML principles, the protocol comprehensively addresses voice and swallowing disorders, which share complex biomechanical and neuromuscular interactions. The relevance of this approach is reinforced by accumulated evidence from voice therapy interventions, such as the LSVT, which have been shown to have positive effects on swallowing functionality, highlighting the functional link between voice and swallowing.[86,87]

The selection of exercises included in the protocol was based on those with demonstrated effects on vocal fold adduction and laryngeal excursion, which are fundamental to laryngeal mechanics during swallowing and phonation.[2,40] This strategic choice aims not only to improve functionality in both areas, but also to facilitate the transfer of therapeutic skills, demonstrating a holistic approach that enhances therapeutic benefits by integrating vocal and swallowing exercises.[17]

The cross-therapy protocol, validated by experts, is notable for its theoretical coherence and practical applicability, demonstrating the importance of consensus in defining clinical practice in areas where direct evidence may be scarce or emerging. This validation process underlines not only the methodological robustness of the protocol, but also its potential to fill an important gap in current clinical practice by providing practitioners with an evidence-based tool for the management of voice and swallowing disorders.

Furthermore, the inclusion of swallowing maneuvers in voice therapy, based on sound principles of EP and ML, suggests a paradigm shifting in the treatment of these disorders, emphasizing the need for interdisciplinary and multifaceted approaches. This protocol represents an innovation in clinical practice, promoting a deeper understanding of the synergies between swallowing and phonation and how these can be optimized to improve patients' quality of life.[52,87]

Finally, the cross-therapy protocol opens up new avenues for future research, encouraging studies to explore not only its clinical efficacy in different populations, but also the underlying mechanisms that facilitate the transfer of benefits between swallowing and voice. Expert validation provides a solid starting point, but it is imperative that future research extends this knowledge by exploring the applicability and efficacy of the protocol in real clinical settings and with a wide range of voice and swallowing disorders.

Limitations

Although a literature review was conducted to construct the protocol design, the selective nature of this process may have limited the inclusion of studies with conflicting or divergent results. This may affect the applicability of the findings and suggests the need for a broader systematic review for future protocol development. The study focused on the validation of a protocol from an expert perspective, without direct implementation in patients. Therefore, the results obtained reflect a theoretical rather than a practical validation, and the effects of the protocol on real patients with voice and swallowing disorders are unknown. Additionally, while the expert panel included voice clinicians with diverse expertise, the protocol primarily addresses hypofunctional laryngeal pathologies. The inclusion of techniques specifically for hyperfunctional disorders, such as resonant voice therapy and flow phonation, will be considered in future research.

Although a panel of qualified experts was available, the limited diversity and number of participants in the validation process may affect the representativeness of the results. Future studies could benefit from including a wider range of professionals and clinical contexts to enrich the validation of the protocol. This will ensure a more comprehensive evaluation, encompassing various therapeutic approaches and voice disorders.

Finally, this study did not include a pilot phase of the protocol in real clinical settings, which limits the understanding of its practical applicability, effectiveness, and patient experience. Future implementation of the protocol in pilot studies will allow adjustments to be made based on direct feedback from patients and clinicians, thereby improving the clinical relevance of the protocol.

CONCLUSION

The cross-therapy protocol developed and validated in this study is considered a breakthrough in the rehabilitation of hypofunctional voice and swallowing disorders by incorporating principles of EP and ML. Specifically, the protocol addresses hypofunctional laryngeal pathologies. Empirical testing is deemed essential to verify its efficacy across different clinical settings. The current validation, based on expert opinion, provides a theoretical foundation but lacks practical application in patient populations. Future research should encompass pilot studies and randomized controlled trials to empirically assess the efficacy and safety of the protocol. This study establishes the groundwork for future research to investigate the practical application of the protocol and its impact on patients. Further empirical studies, including systematic reviews and meta-analyses, are necessary to refine and validate the protocol, ultimately leading to more integrative and evidence-based treatments in speech therapy practice. This iterative approach is expected to ensure that the protocol evolves to meet diverse clinical needs and improve patient outcomes in a holistic manner.

Declaration of Competing Interest

None.

APPENDIX 1. Aspects to Evaluate for Each Category of the Protocol

Clarity: Recognized as what is intended when expressing an idea, statement, or theme, being understood perfectly without room for vague interpretations. A clear expression is easy to understand and intelligible.
Sufficiency: Defined as the minimum capacity or aptitude for something, established from meeting the requirements for solving a problem or carrying out a specific project.
Relevance: Focuses on the fundamental, transcendent, or substantial, which therefore carries importance for the topic being discussed. In research topics, it is defined as the importance of what is proposed in relation to the main theme.
Coherence: Defined as the characteristic of the overall plan, maintaining a sequential structure and systematically developed. It is primarily a logical relationship between the whole and its parts, so that no contradiction occurs between them.

Category	Sufficiency	Coherence	Relevance	Clarity
Biomechanical behavior to work on	1: The biomechanical behavior is not sufficient to be considered as a rehabilitative element in swallowing and voice. 2: The biomechanical behavior may be sufficient to be considered as a rehabilitative element in swallowing and voice, however, it needs redirection. 3: The biomechanical behavior is sufficient to be considered as a rehabilitative element in swallowing and voice.	1: The biomechanical behavior is not coherent with what is intended to work on. 2: The biomechanical behavior is moderately coherent with what is intended to work on. 3: The biomechanical behavior is coherent with what is intended to work on.	1: The biomechanical behavior to work on is not relevant for the rehabilitation of swallowing and voice. 2: The biomechanical behavior to work on is moderately relevant for the rehabilitation of swallowing and voice. 3: The biomechanical behavior to work on is relevant for the rehabilitation of swallowing and voice.	1: The biomechanical behavior is not clear according to what is expected to work on. 2: The biomechanical behavior is moderately clear according to what is expected to work on. 3: The biomechanical behavior is clear according to what is expected to work on.
Instruction	1: The instructions are unclear and difficult to understand. 2: The instructions are understandable but could be improved. 3: The instructions are clear, concise, and easy to follow.	1: The instructions are not related to the rehabilitation objectives. 2: The instructions have some coherence but can be improved. 3: The instructions are coherent with the principles and objectives.	1: The instructions do not address the specific needs of the patient. 2: The instructions are relevant but could be better adapted to each case. 3: The instructions are highly relevant and tailored to the needs of the patient.	1: The instructions are disorganized and ambiguous. 2: The instructions are understandable but could be more precise. 3: The instructions are organized and unambiguous.
Pre practice	1: The prepractice is not sufficient to achieve the implementation of Cross-Therapy. 2: The prepractice is moderately sufficient to achieve the implementation of Cross-Therapy. 3: The prepractice is sufficient to achieve the implementation of Cross-Therapy.	1: The prepractice is not coherent with the objective of the Cross-Therapy approach. 2: The prepractice is moderately coherent with the objective of the Cross-Therapy approach. 3: The prepractice is coherent with the objective of the Cross-Therapy approach.	1: The prepractice is not relevant for fulfilling the Cross-Therapy approach. 2: The pre-practice is moderately relevant for fulfilling the Cross-Therapy approach. 3: The pre-practice and practice are relevant for fulfilling the Cross-Therapy approach.	1: The instructions for the pre-practice are not clear to carry out the approach. 2: The instructions for the pre-practice are moderately clear to carry out the approach. 3: The instructions for the pre-practice are clear to carry out the approach.
Practice	1: The practice is not sufficient to achieve the implementation of Cross-Therapy. 2: The practice is moderately sufficient to achieve the implementation of Cross-Therapy. 3: The practice is sufficient to achieve the implementation of Cross-Therapy.	1: The practice is not coherent with the objective of the Cross-Therapy approach. 2: The practice is moderately coherent with the objective of the Cross-Therapy approach. 3: The practice is coherent with the objective of the Cross-Therapy approach.	1: The practice is not relevant for fulfilling the Cross-Therapy approach. 2: The practice is moderately relevant for fulfilling the Cross-Therapy approach. 3: The practice is relevant for fulfilling the Cross-Therapy approach.	1: The instructions for the practice are not clear to carry out the approach. 2: The instructions for the practice are moderately clear to carry out the approach. 3: The instructions for the practice are clear to carry out the approach.

Retention/ transfer measures	1: There are not enough transfer measures included to observe the impact of the therapy.	1: The transfer measures are not aligned with the therapeutic progression.	1: The proposed transfer measures are not relevant in the therapeutic process.	1: The transfer measures are not clearly presented and are not easy to understand.
	2: The transfer measures are clear but not sufficient to observe the impact of the therapy.	2: The transfer measures are moderately aligned with the therapeutic progression.	2: The proposed transfer measures are moderately relevant in the therapeutic process.	2: The transfer measures could be clearer, and their understanding is not entirely easy.
	3: There are enough transfer measures included to observe the impact of the therapy.	3: The transfer measures are aligned with the therapeutic progression.	3: The proposed transfer measures are relevant in the therapeutic process.	3: The transfer measures are clearly presented and are easy to understand.

APPENDIX 2. Therapy Protocol's Validation Instrument

Dear expert: This study aims to validate the content of a cross-therapy protocol for swallowing and voice disorders. It is based on four swallowing maneuvers/exercises that address shared and critical biomechanical components of swallowing and phonation.Because of your broad expertise and knowledge in this field, we kindly ask you to assess the protocol, considering that every maneuver/exercise included has the following specifications:
1. The biomechanical component that the exercise/maneuver addresses at the phonatory and swallowing level.
2. Its original instructions based on literature.
3. The conditions of prepractice and practice, as well as the retention measures, according to ML principles.
Please rate the sufficiency, coherence, relevance, and clarity of the previously mentioned protocol content, assigning a score of 1–3, according to the instructions of the validation instrument attached to this form.

			Motor learning principle approach			
	Biomechanical component	Original instruction of the maneuver/exercise	Pre practice	Practice	Retention measures	
Maneuver/Exercise	Score (1–3)	Score (1–3)	Score (1–3)	Score (1–3)	Score (1–3)	Comments
1. Supraglottic swallow	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance Clarity:	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	
2. Mendelsohn maneuver	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	
3. Shaker exercise	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	
4. Effortful swallow	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	Sufficiency: Coherence: Relevance: Clarity:	

References

1. Rousseau B, Branski R. *Anatomy and Physiology of Speech and Hearing*. Thieme Medical Publishers; 2018.
2. Venkatraman A, Fujiki RB, Craig B, et al. Determining the underlying relationship between swallowing and maximum vocal pitch elevation: a preliminary study of their hyoid biomechanics in healthy adults, 2020. Available at: https://www.semanticscholar.org/paper/Determining-the-Underlying-Relationship-Between-and-Venkatraman-Fujiki/ea8156f9a17083261f0af61b5206ffe33afb637b. Accessed October 31, 2022.
3. Yamaguchi S, Ishida M, Hidaka K, et al. Relationship between swallowing function and breathing/phonation. *Auris Nasus Larynx.* 2018;45:533–539. https://doi.org/10.1016/j.anl.2017.08.009.
4. Kaspar K, Ekberg O. Identifying vulnerable patients: role of the EAT-10 and the multidisciplinary team for early intervention and comprehensive dysphagia care. *Nestle Nutr Inst Workshop Ser.* 2012;72:19–31. https://doi.org/10.1159/000339977.
5. Vose A, Humbert I. 'Hidden in plain sight': a descriptive review of laryngeal vestibule closure. *Dysphagia.* 2019;34:281–289. https://doi.org/10.1007/s00455-018-9928-1.
6. Zhang Z. Mechanics of human voice production and control. *J Acoust Soc Am.* 2016;140:2614–2635. https://doi.org/10.1121/1.4964509.
7. Brodsky MB, Akst LM, Jedlanek E, et al. Laryngeal injury and upper airway symptoms after endotracheal intubation during surgery: a systematic review and meta-analysis. *Anesth Analg.* 2021;132:1023–1032. https://doi.org/10.1213/ANE.0000000000005276.

8. DePietro JD, Rubin S, Stein DJ, et al. Laryngeal manipulation for dysphagia with muscle tension dysphonia. *Dysphagia.* 2018;33:468–473. https://doi.org/10.1007/s00455-018-9875-x.
9. Ollivere B, Duce K, Rowlands G, et al. Swallowing dysfunction in patients with unilateral vocal fold paralysis: aetiology and outcomes. *J Laryngol Otol.* 2006;120:38–41. https://doi.org/10.1017/S0022215105003567.
10. Starmer HM, Tippett DC, Webster KT. Effects of laryngeal cancer on voice and swallowing. (vii). *Otolaryngol Clin N Am.* 2008;41:793–818. https://doi.org/10.1016/j.otc.2008.01.018.
11. Daniels SK, Brailey K, Priestly DH, et al. Aspiration in patients with acute stroke. *Arch Phys Med Rehabil.* 1998;79:14–19. https://doi.org/10.1016/s0003-9993(98)90200-3.
12. Park A, Jang S-J, Kim N-E, et al. Swallowing outcomes following voice therapy in multiple system atrophy with dysphagia: comparison of treatment efficacy with Parkinson's disease. *Dysphagia.* 2022;37:198–206. https://doi.org/10.1007/s00455-021-10265-9.
13. Easterling C. Does an exercise aimed at improving swallow function have an effect on vocal function in the healthy elderly? *Dysphagia.* 2008;23:317–326. https://doi.org/10.1007/s00455-008-9158-z.
14. Fujiki RB, Oliver AJ, Sivasankar MP, et al. Secondary voice outcomes of a randomized clinical trial comparing two head/neck strengthening exercises in healthy older adults: a preliminary report. *J Speech Lang Hear Res.* 2019;62:318–323. https://doi.org/10.1044/2018_JSLHR-S-18-0338.
15. Liaw M-Y, Hsu C-H, Leong C-P, et al. Respiratory muscle training in stroke patients with respiratory muscle weakness, dysphagia, and dysarthria - a prospective randomized trial. *Medicine.* 2020;99:e19337. https://doi.org/10.1097/MD.0000000000019337.
16. Lowell SY, Colton RH, Kelley RT, et al. Isolated and combined respiratory training for muscle tension dysphonia: preliminary findings. *J Voice.* 2022;36:361–382. https://doi.org/10.1016/j.jvoice.2020.06.013.
17. Balou M, Herzberg EG, Kamelhar D, et al. An intensive swallowing exercise protocol for improving swallowing physiology in older adults with radiographically confirmed dysphagia. *CIA.* 2019;14:283–288. https://doi.org/10.2147/CIA.S194723.
18. Luchesi KF, Kitamura S, Mourão LF. Management of dysphagia in Parkinson's disease and amyotrophic lateral sclerosis. *Codas.* 2013;25:358–364. https://doi.org/10.1590/s2317-17822013000400010.
19. Mavrea S, Regan J. The diagnostic accuracy of the pitch glide to identify aspiration in patients with respiratory diseases: a pilot study. *Folia Phoniatr Logop.* 2020;72:331–340. https://doi.org/10.1159/000501451.
20. Rajappa AT, Soriano KR, Ziemer C, et al. Reduced maximum pitch elevation predicts silent aspiration of small liquid volumes in stroke patients. *Front Neurol.* 2017;8:436. https://doi.org/10.3389/fneur.2017.00436.
21. Yilmaz C, Bostancı Ö, Bulut S. Effect of respiratory muscle training on pitch range and sound duration in brass instrument players and singers. *J Voice.* 2022;36:76–82. https://doi.org/10.1016/j.jvoice.2020.04.012.
22. Shaker R, Lang IM. Reflex mediated airway protective mechanisms against retrograde aspiration. *Am J Med.* 1997;103:64S–73S. https://doi.org/10.1016/S0002-9343(97)00326-4.
23. Eriksson H, Tuomi L, Finizia C. Voice outcomes following head-lift exercises in head and neck cancer: a randomized controlled study. *J Voice.* 2023;37:226–233. https://doi.org/10.1016/j.jvoice.2020.12.015.
24. Fujiki RB, Oliver AJ, Malandraki JB, et al. The recline and head lift exercises: a randomized clinical trial comparing biomechanical swallowing outcomes and perceived effort in healthy older adults. *J Speech Lang Hear Res.* 2019;62:631–643. https://doi.org/10.1044/2018_JSLHR-S-18-0117.
25. Nasrin S, Ali D, Jamshid J, et al. The effects of Cricothyroid Visor Maneuver (CVM) therapy on the voice characteristics of patients with muscular tension dysphonia: a case series study. *J Voice.* 2022. https://doi.org/10.1016/j.jvoice.2022.02.016.S0892-1997(22)00056-X, Epub ahead of print.
26. Mercer E, Lowell SY. The low mandible maneuver: preliminary study of its effects on aerodynamic and acoustic measures. *J Voice.* 2020;34:645.e1–645.e9. https://doi.org/10.1016/j.jvoice.2018.12.005.
27. Salturk Z, Ustun O, Lutfi T, et al. Vocal function following frontolateral laryngectomy. *Eur J Med Res.* 2020;36:98–101. https://doi.org/10.4274/eamr.galenos.2019.98608.
28. Shaker R. *Manual of Diagnostic and Therapeutic Techniques for Disorders of Deglutition.* Springer; 2013.
29. Shaker R, Easterling C, Kern M, et al. Rehabilitation of swallowing by exercise in tube-fed patients with pharyngeal dysphagia secondary to abnormal UES opening. *Gastroenterology.* 2002;122:1314–1321. https://doi.org/10.1053/gast.2002.32999.
30. Langmore SE, Pisegna JM. Efficacy of exercises to rehabilitate dysphagia: a critique of the literature. *Int J Speech Lang Pathol.* 2015;17:222–229. https://doi.org/10.3109/17549507.2015.1024171.
31. Bülow M, Olsson R, Ekberg O. Videomanometric analysis of supraglottic swallow, effortful swallow, and chin tuck in patients with pharyngeal dysfunction. *Dysphagia.* 2001;16:190–195. https://doi.org/10.1007/s00455-001-0065-9.
32. Hind JA, Nicosia MA, Roecker EB, et al. Comparison of effortful and noneffortful swallows in healthy middle-aged and older adults. *Arch Phys Med Rehabil.* 2001;82:1661–1665. https://doi.org/10.1053/apmr.2001.28006.
33. Hiss SG, Huckabee ML. Timing of pharyngeal and upper esophageal sphincter pressures as a function of normal and effortful swallowing in young healthy adults. *Dysphagia.* 2005;20:149–156. https://doi.org/10.1007/s00455-005-0008-y.
34. Felix VN, Corrêa SMA, Soares RJ. A therapeutic maneuver for oropharyngeal dysphagia in patients with Parkinson's disease. *Clinics.* 2008;63:661–666. https://doi.org/10.1590/s1807-59322008000500015.
35. Bahia MM, Lowell SY. Surface electromyographic activity of the masseter muscle during regular and effortful saliva swallows: a preliminary study. *Dysphagia.* 2024;39:231–240. https://doi.org/10.1007/s00455-023-10605-x.
36. Inamoto Y, Saitoh E, Ito Y, et al. The Mendelsohn maneuver and its effects on swallowing: kinematic analysis in three dimensions using dynamic area detector CT. *Dysphagia.* 2018;33:419–430. https://doi.org/10.1007/s00455-017-9870-7.
37. Jang HJ, Leigh JH, Seo HG, et al. Effortful swallow enhances vertical hyolaryngeal movement and prolongs duration after maximal excursion. *J Oral Rehabil.* 2015;42:765–773. https://doi.org/10.1111/joor.12312.
38. Molfenter SM, Hsu C-Y, Lu Y, et al. Alterations to swallowing physiology as the result of effortful swallowing in healthy seniors. *Dysphagia.* 2018;33:380–388. https://doi.org/10.1007/s00455-017-9863-6.
39. Imada M, Kagaya H, Ishiguro Y, et al. Effect of visual biofeedback to acquire supraglottic swallow in healthy individuals: a randomized-controlled trial. *Int J Rehabil Res.* 2016;39:181–184. https://doi.org/10.1097/MRR.0000000000000154.
40. Martin BJ, Logemann JA, Shaker R, et al. Normal laryngeal valving patterns during three breath-hold maneuvers: a pilot investigation. *Dysphagia.* 1993;8:11–20. https://doi.org/10.1007/BF01351472.
41. Kasahara T, Hanayama K, Kodama M, et al. The efficacy of supraglottic swallow as an indirect swallowing exercise by analysis of hyoid bone movement. *Tokai J Exp Clin Med.* 2009;34:72–75.
42. Lazarus C, Logemann JA, Gibbons P. Effects of maneuvers on swallowing function in a dysphagic oral cancer patient. *Head Neck.* 1993;15:419–424. https://doi.org/10.1002/hed.2880150509.
43. Rofes L, Arreola V, Almirall J, et al. Diagnosis and management of oropharyngeal Dysphagia and its nutritional and respiratory complications in the elderly. *Gastroenterol Res Pract.* 2011;2011:818979. https://doi.org/10.1155/2011/818979.
44. Iyomasa RM, Tagliarini JV, Rodrigues SA, et al. Laryngeal and vocal alterations after thyroidectomy. *Braz J Otorhinolaryngol.* 2019;85:3–10. https://doi.org/10.1016/j.bjorl.2017.08.015.
45. Szkiełkowska A, Krasnodębska P, Miaśkiewicz B, et al. Electroglottography in the diagnosis of functional dysphonia. *Eur Arch Otorhinolaryngol.* 2018;275:2523–2528. https://doi.org/10.1007/s00405-018-5012-6.
46. Burkhead LM, Sapienza CM, Rosenbek JC. Strength-training exercise in dysphagia rehabilitation: principles, procedures, and

directions for future research. *Dysphagia.* 2007;22:251–265. https://doi.org/10.1007/s00455-006-9074-z.
47. Zimmerman E, Carnaby G, Lazarus CL, et al. Motor learning, neuroplasticity, and strength and skill training: moving from compensation to retraining in behavioral management of dysphagia. *Am J Speech Lang Pathol.* 2020;29(2S):1065–1077. https://doi.org/10.1044/2019_AJSLP-19-00088.
48. Robbins J, Kays SA, Gangnon RE, et al. The effects of lingual exercise in stroke patients with dysphagia. *Arch Phys Med Rehabil.* 2007;88:150–158. https://doi.org/10.1016/j.apmr.2006.11.002.
49. Robbins J, Gangnon RE, Theis SM, et al. The effects of lingual exercise on swallowing in older adults. *J Am Geriatr Soc.* 2005;53:1483–1489. https://doi.org/10.1111/j.1532-5415.2005.53467.x.
50. Clark HM, O'Brien K, Calleja A, et al. Effects of directional exercise on lingual strength. *J Speech Lang Hear Res.* 2009;52:1034–1047. https://doi.org/10.1044/1092-4388(2009/08-0062).
51. Van den Steen L, Vanderwegen J, Guns C, et al. Tongue-strengthening exercises in healthy older adults: does exercise load matter? A randomized controlled trial. *Dysphagia.* 2019;34:315–324. https://doi.org/10.1007/s00455-018-9940-5.
52. Niu C, Zhou W, Wang H, et al. The effect of voice training interventions on patients with oropharyngeal dysphagia: a systematic review. *Eur Arch Otorhinolaryngol.* 2023;280:973–984. https://doi.org/10.1007/s00405-022-07719-7.
53. Hubackova S. Seminar text of German in blended learning. *Procedia Soc Behav Sci.* 2014;112:413–417. https://doi.org/10.1016/j.sbspro.2014.01.1183.
54. Aihara K, Inamoto Y, Kanamori D, et al. Effect of tongue-hold swallow on posterior pharyngeal wall using dynamic area detector computed tomography. *J Oral Rehabil.* 2021;48:1235–1242. https://doi.org/10.1111/joor.13246.
55. Aoyagi Y, Ohashi M, Ando S, et al. Effect of tongue-hold swallow on pharyngeal contractile properties in healthy individuals. *Dysphagia.* 2021;36:936–943. https://doi.org/10.1007/s00455-020-10217-9.
56. Wang Z, Fang Q, Li H, et al. Effect of expiratory muscle strength training on swallowing and cough functions in patients with neurological diseases: a meta-analysis. *Am J Phys Med Rehabil.* 2019;98:1060–1066.
57. Barikroo A, Im I, Crary M, et al. Effects of age and lingual-palatal pressure levels on submental surface electromyography measures. *Dysphagia.* 2023;38:1277–1285. https://doi.org/10.1007/s00455-023-10553-6.
58. Oh J-C. Effects of effortful swallowing exercise with progressive anterior tongue press using Iowa Oral Performance Instrument (IOPI) on the strength of swallowing-related muscles in the elderly: a preliminary study. *Dysphagia.* 2022;37:158–167. https://doi.org/10.1007/s00455-021-10259-7.
59. Sapir S, Ramig LO, Fox CM. Intensive voice treatment in Parkinson's disease: Lee Silverman Voice Treatment. *Expert Rev Neurother.* 2011;11:815–830. https://doi.org/10.1586/ern.11.43.
60. Fujimaki Y, Tsunoda K, Kobayashi R, et al. Independent exercise for glottal incompetence to improve vocal problems and prevent aspiration pneumonia in the elderly: a randomized controlled trial. *Clin Rehabil.* 2017;31:1049–1056. https://doi.org/10.1177/0269215516673208.
61. Krekeler BN, Rowe LM, Connor NP. Dose in exercise-based dysphagia therapies: a scoping review. *Dysphagia.* 2021;36:1–32. https://doi.org/10.1007/s00455-020-10104-3.
62. Logemann JA, Pauloski BR, Rademaker AW, et al. Speech and swallowing rehabilitation for head and neck cancer patients. *Oncology.* 1997;11:651–656.659; discussion 659, 663–664.
63. Langmore SE, McCulloch TM, Krisciunas GP, et al. Efficacy of electrical stimulation and exercise for dysphagia in patients with head and neck cancer: a randomized clinical trial. *Head Neck.* 2016;38(Suppl 1):E1221–E1231. https://doi.org/10.1002/hed.24197.
64. Mattioli F, Bergamini G, Alicandri-Ciufelli M, et al. The role of early voice therapy in the incidence of motility recovery in unilateral vocal fold paralysis. *Logop Phoniatr Vocol.* 2011;36:40–47. https://doi.org/10.3109/14015439.2011.554433.
65. Santos M, Vaz Freitas S, Santos P, et al. Unilateral vocal fold paralysis and voice therapy: does age matter? A prospective study with 100 consecutive patients. *Ear Nose Throat J.* 2021;100(5_suppl):489S–494S. https://doi.org/10.1177/0145561319882116.
66. McCullough GH, Kamarunas E, Mann GC, et al. Effects of Mendelsohn maneuver on measures of swallowing duration post stroke. *Top Stroke Rehabil.* 2012;19:234–243. https://doi.org/10.1310/tsr1903-234.
67. Ohba S, Yokoyama J, Kojima M, et al. Significant preservation of swallowing function in chemoradiotherapy for advanced head and neck cancer by prophylactic swallowing exercise. *Head Neck.* 2016;38:517–521. https://doi.org/10.1002/hed.23913.
68. Azola AM, Greene LR, Taylor-Kamara I, et al. The relationship between submental surface electromyography and hyo-laryngeal kinematic measures of Mendelsohn Maneuver duration. *J Speech Lang Hear Res.* 2015;58:1627–1636. https://doi.org/10.1044/2015_JSLHR-S-14-0203.
69. Wheeler-Hegland K, Ashford J, Frymark T, et al. Evidence-based systematic review: oropharyngeal dysphagia behavioral treatments. Part II–impact of dysphagia treatment on normal swallow function. *J Rehabil Res Dev.* 2009;46:185–194.
70. Kwong E, Ng K-WK, Leung M-T, et al. Application of ultrasound biofeedback to the learning of the Mendelsohn Maneuver in non-dysphagic adults: a pilot study. *Dysphagia.* 2021;36:650–658. https://doi.org/10.1007/s00455-020-10179-y.
71. Peng C-H, Pauloski BR. Ultrasonography as biofeedback to increase muscle activation during the Mendelsohn Maneuver in healthy adults. *Dysphagia.* 2023;38:1156–1168. https://doi.org/10.1007/s00455-022-10542-1.
72. McCullough GH, Kim Y. Effects of the Mendelsohn maneuver on extent of hyoid movement and UES opening post-stroke. *Dysphagia.* 2013;28:511–519. https://doi.org/10.1007/s00455-013-9461-1.
73. Hertegård S. What have we learned about laryngeal physiology from high-speed digital videoendoscopy? *Curr Opin Otolaryngol Head Neck Surg.* 2005;13:152–156. https://doi.org/10.1097/01.moo.0000163451.98079.ba.
74. Hong YT, Hong KH, Jun J-P, et al. The effects of dynamic laryngeal movements on pitch control. *Am J Otolaryngol.* 2015;36:660–665. https://doi.org/10.1016/j.amjoto.2015.05.002.
75. Easterling C, Grande B, Kern M, et al. Attaining and maintaining isometric and isokinetic goals of the Shaker exercise. *Dysphagia.* 2005;20:133–138. https://doi.org/10.1007/s00455-005-0004-2.
76. Huckabee M-L, Macrae P. *Effortful swallow. En Manual of Diagnostic and Therapeutic Techniques for Disorders of Deglutition.* New York: Springer; 2013:281–298.
77. Archer SK, Iezzi CM, Gilpin L. Swallowing and voice outcomes in patients hospitalized with COVID-19: an observational cohort study. *Arch Phys Med Rehabil.* 2021;102:1084–1090. https://doi.org/10.1016/j.apmr.2021.01.063.
78. Galek K, Bice EM, Marquez G. Tongue and lip comparisons between healthy and nondysphagic poststroke individuals. *Folia Phoniatr Logop.* 2022;74:46–53. https://doi.org/10.1159/000517170.
79. Park SK, Ko G, Choi GJ, et al. Comparison between supraglottic airway devices and endotracheal tubes in patients undergoing laparoscopic surgery: a systematic review and meta-analysis. *Medicine.* 2016;95:e4598. https://doi.org/10.1097/MD.0000000000004598.
80. Balou M, Herzberg EG, Kamelhar D, et al. An intensive swallowing exercise protocol for improving swallowing physiology in older adults with radiographically confirmed dysphagia. *CIA.* 2019;14:283–288. https://doi.org/10.2147/CIA.S194723.
81. Kahrilas PJ, Logemann JA, Krugler C, et al. Volitional augmentation of upper esophageal sphincter opening during swallowing. Pt 1 *Am J Physiol.* 1991;260:G450–456. https://doi.org/10.1152/ajpgi.1991.260.3.G450.
82. Antunes EB, Lunet N. Effects of the head lift exercise on the swallow function: a systematic review. *Gerodontology.* 2012;29:247–257. https://doi.org/10.1111/j.1741-2358.2012.00638.x.
83. Sze WP, Yoon WL, Escoffier N, et al. Evaluating the training effects of two swallowing rehabilitation therapies using surface electromyography–Chin Tuck Against Resistance (CTAR) exercise and the

shaker exercise. *Dysphagia.* 2016;31:195–205. https://doi.org/10.1007/s00455-015-9678-2.

84. Archer SK, Smith CH, Newham DJ. Surface electromyographic biofeedback and the effortful swallow exercise for stroke-related dysphagia and in healthy ageing. *Dysphagia.* 2021;36:281–292. https://doi.org/10.1007/s00455-020-10129-8.
85. Wheeler-Hegland KM, Rosenbek JC, Sapienza CM. Submental sEMG and hyoid movement during Mendelsohn maneuver, effortful swallow, and expiratory muscle strength training. *J Speech Lang Hear Res.* 2008;51:1072–1087. https://doi.org/10.1044/1092-4388(2008/07-0016).
86. Nozaki S, Fujiu-kurachi M, Tanimura T, et al. Effects of Lee Silverman Voice Treatment (LSVT LOUD) on swallowing in patients with progressive supranuclear palsy: a pilot study. *Prog Rehabil Med.* 2021;6:20210012. https://doi.org/10.2490/prm.20210012.
87. Sharkawi AE. Swallowing and voice effects of Lee Silverman Voice Treatment (LSVT(R)): a pilot study. *J Neurol Neurosurg Psychiatry.* 2002;72:31–36. https://doi.org/10.1136/jnnp.72.1.31.