Training to Analyze Functional Parameters with Fiberoptic Endoscopic Evaluation of Swallowing: A Scoping Review

Bianca O. I. Costa[1] · Liliane S. Machado[1] · Milena M. Augusto[2] · Desiré D. D. Magalhães[1] · Thaís Coelho Alves[3] · Leandro Pernambuco[1,4]

Abstract
Analyzing fiberoptic endoscopic evaluation of swallowing (FEES) is challenging and requires training to ensure the proficiency of health professionals and improve reliability. This scoping review aims to identify and map the available evidence on training health professionals to analyze FEES functional parameters. The method proposed by the Joanna Briggs Institute and the PRISMA-ScR guidelines were followed. The search was performed in MEDLINE, Cochrane Library, Embase, Web of Science, Scopus, CINAHL databases, and in the gray literature. Two blinded independent reviewers screened articles by title and abstract. Then, they read the full text of the included reports, considering the eligibility criteria. Data were extracted using a standardized form. Six studies met the established eligibility criteria, published between 2009 and 2022, with few participants. All these studies addressed training as part of the process to validate a rating scale. No standardized criteria were observed regarding the selection of experts and participants, training structure, and outcome measures to assess participants' competence. The reviewed literature indicates that training must be developed to equip students and health professionals who treat dysphagia, enabling them to analyze the functional parameters of the FEES, considering variables that may influence the participants' performance.

Keywords Swallowing · Deglutition disorders · Endoscopy · Education · Training

Introduction

The use of Fiberoptic Endoscopic Evaluation of Swallowing (FEES) as an instrumental assessment is widely known. FEES arose from the possibility of accurate and dynamic visualization of anatomical structures of the laryngopharyngeal region before and after swallowing [1, 2]. Despite being frequently used in the clinical context, the analysis of swallowing parameters through the FEES uses visual perception and is therefore subjective, as it depends on the rater's inspection and interpretation of the image (as in other imaging tests in the area of health) [3]. This procedure requires visual and cognitive perception skills, considering that visualization skills can be improved with experience and vary according to the speed of thought and ability to recognize patterns and encode, retain, and retrieve information [4].

The literature describes the degree of variation in how FEES parameters are interpreted [5, 6]. The classification of pharyngeal residues and the interpretation of penetration and aspiration events are frequently reported difficulties in functional assessment [7]. Therefore, visual-perceptual skills

✉ Leandro Pernambuco
leandroapernambuco@gmail.com

1 Graduate Program in Decision and Health Models (PPGMDS/UFPB), Universidade Federal da Paraíba (UFPB), Campus I s/n, Conj. Pres. Castelo Branco III, João Pessoa, PB 58050-585, Brazil

2 Technological Innovation in Health Laboratory (LAIS/UFRN), Universidade Federal do Rio Grande do Norte (UFRN), Av. Nilo Peçanha, 650, Petrópolis, Natal, RN 59012-300, Brazil

3 Dysphagia Research and Rehabilitation Laboratory (LADis/UNESP), Universidade Estadual Paulista (UNESP), Campus I 737, Av. Hygino Muzzi Filho, Marília, SP 17.525-900, Brazil

4 Department of Speech, Language and Hearing Sciences, Universidade Federal da Paraíba (UFPB), Campus I s/n, Conj. Pres. Castelo Branco III, João Pessoa, PB 58051-900, Brazil

training has been proposed and carried out to improve the classification of these and other parameters in diagnosing dysphagia [8–10].

Curtis et al. [7] developed a training framework to classify pharyngeal residue, penetration, and aspiration, using a new visual-perceptual classification scale of anatomical definitions. Inexperienced evaluators significantly improved the accuracy of measure classification. This result suggests that structured training curricula can effectively develop skills to interpret FEES functional findings more accurately [11].

Studies show that training for the analysis of FEES has improved inter- and intra-examiner reliability [7, 9, 12]. However, subjectivity in this analysis remains a challenge. Therefore, it is essential to standardize FEES functional analysis methods and train visual-perceptual skills. Based on professional training to analyze FEES parameters, it is possible to increase the reliability of exam classifications, make analyses reproducible, establish criteria for proficiency, and improve the clinical management of dysphagia [13].

FEES mains steps include the evaluation of the swallowing endoscopic anatomy, pharyngeal and laryngeal sensory-motor function, saliva and bolus management, and the effectiveness of compensatory strategies [1, 13]. For this study, we focused on bolus management, which we named here as functional parameters. Hence, this scoping review aimed to identify and map the available evidence on the training of visual-perceptual skills of students and health professionals for the analysis of the functional parameters of swallowing obtained with FEES in adults. To achieve this objective, we sought to:

1. Identify the training methods that currently exist to analyze FEES and which functional parameters are usually considered in training.
2. Describe the characteristics and contents of training in the analysis of FEES functional parameters for health professionals.
3. Identify diagnostic accuracy indicators related to training in the functional analysis of FEES, summarizing the available evidence.
4. Point out gaps in the topic and the most urgent issues to be solved in future research.

The scoping review focused on the following question: "How is the training of students and health professionals carried out to analyze the functional parameters in the FEES exams of adults with oropharyngeal dysphagia?".

Methods

In line with indications for scoping reviews, compared to systematic reviews by Munn et al. [14], this study sought to determine the scope of the literature covering visual-perceptual skills training to analyze functional parameters of the FEES to provide an overview of the topic and indicate existing gaps. We conducted this scoping review using the Joanna Briggs Institute (JBI) methodology [15]. The objectives, inclusion criteria, analysis methods, and data presentation methods are previously specified and reported in an a priori protocol [16]. We followed the recommendations for preparing scoping reviews of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols—extension for scoping reviews (PRISMA-ScR) [17] (Supplementary Material 1). The protocol of this review was registered in the Open Science Framework on November 10, 2021 (https://osf.io/4xst5/).

The PCC strategy (population, concept, and context) [15] was used to select studies: (a) regarding the population: individuals being trained for the functional analysis of FEES in adults (i.e., speech-language-hearing therapists, otorhinolaryngologists, neurologists, or general practitioners, as well as undergraduate and graduate students in these specialties); (b) regarding the concept: training to analyze the functional parameters of FEES (training is defined here as an educational procedure aiming to enable individuals to develop an activity, through instruction or guidance); (c) regarding the context: studies carried out in training environments, whether clinical, hospital, institutional, virtual environments and so forth.

Search Strategies

We identified published and unpublished studies through a comprehensive search strategy. We searched the following electronic databases: MEDLINE (PubMed), Cochrane Library, Embase (Elsevier), Web of Science (Clarivate), Scopus (Elsevier), and CINAHL Full Text (EBSCO). Sources of unpublished studies and the gray literature include Google Scholar, ProQuest, and MedNar. All searches were made in advanced mode, with no restriction on language. The survey was completed on December 16, 2021.

We used a three-step search approach to identify relevant studies [18]. In step 1, a search strategy was developed for MEDLINE (reported in a previous study) [16], using words contained in titles, abstracts, and keywords of articles relevant to the topic. In step 2, we performed an extensive search, including all identified index terms and keywords on the databases (Supplementary Material 2). In step 3, the reference lists of all included articles were manually searched to verify the existence of relevant studies on the topic.

Selection of Studies

After the search, we followed a series of steps:

1. We imported identified articles into Rayyan (Qatar Computing Research Institute, Doha, Qatar), a free online software application for web and mobile that allows blinding collaboration between reviewers and improves data screening.
2. Duplicate papers were identified and removed.
3. Two independent blinded reviewers screened each article's abstract for inclusion or exclusion.
4. We kept a record of decisions on the platform.
5. We retrieved full texts of included abstracts and considered them for review.

The above steps were initially conducted by two independent reviewers. When there were disagreements in reading abstracts or full texts, the conflicts would be discussed and resolved by consensus. If this was not possible, a third reviewer would be called.

The following inclusion criteria were applied to select studies by their title and abstract:

- Studies related to training for the analysis of the functional parameters of FEES applied to undergraduate and graduate students or health professionals.
- In any language, to cover all sources of national and international literature.
- Publications since 1988, when FEES was formally described [2];
- Published and unpublished evidence on the subject: Peer-reviewed journals, textbooks, editorials, conference proceedings, and dissertations/theses, considering that the scope review design advocates collecting data from multiple sources [19];
- Studies that were carried out in any training environment, whether in person or remotely.

The exclusion criterion considered for this step was:

- Studies that evaluate dysphagia at the esophageal level.

For the full text selection stage, all inclusion and exclusion criteria applied in the previous stage were considered, with the addition of the following exclusion criteria:

- Studies that do not describe the training and present only the results.

The detailed inclusion criteria of this review are specified considering the population, concept, context (PCC) strategy, and types of evidence sources, summarized in Table 1.

Data Extraction

Data were extracted from the studies included in the review by one reviewer (BC) and independently corroborated by two other reviewers (LM and LP), using a data extraction tool developed in the review protocol [16]. We refined the preliminary data extraction tool while extracting data from included publications. Data encompassed details of study characteristics and training content, both of significance for the specific purpose of the scoping review.

Some information provided in the previously published protocol [16] was not reported, as it is not described in most studies related to training in the analysis of FEES functional parameters. These changes can be reported due to the scoping review's iterative nature. The variables were: diagnosis of the population evaluated in the FEES exam; how the food was offered (utensils, volumes, consistencies); use and characteristics of the dye; use of an anesthetic; the learning curve and self-assessment in the study; and presentation of a performance report to the participant.

Data Analysis and Presentation

The data extracted in this review are presented in schematics and tables, as the scoping review guidelines recommended. The presentations accompany a narrative summary in the body of the text.

Results

The search in the databases resulted in the identification of 3111 papers. After removing duplicates, 783 were removed. Of the 2328 remaining papers, we excluded 2307 after reading the titles and abstracts. Twenty-one articles were selected

Table 1 Eligibility criteria

Population	Undergraduate or graduate students or health professionals who have undergone training for the analysis of FEES[a] functional parameters
Concept	Training for the analysis of FEES[a] functional parameters using tests performed in the population over 18 years of age
Context	Studies carried out in training environments (clinical, hospital, institutional, virtual environment, and so forth)
Types of evidence sources	Peer-reviewed journals, textbooks, editorials, conference proceedings, and dissertations/theses; in any language so that all sources of national and international literature can be covered; published from 1988 onwards; on the established bases

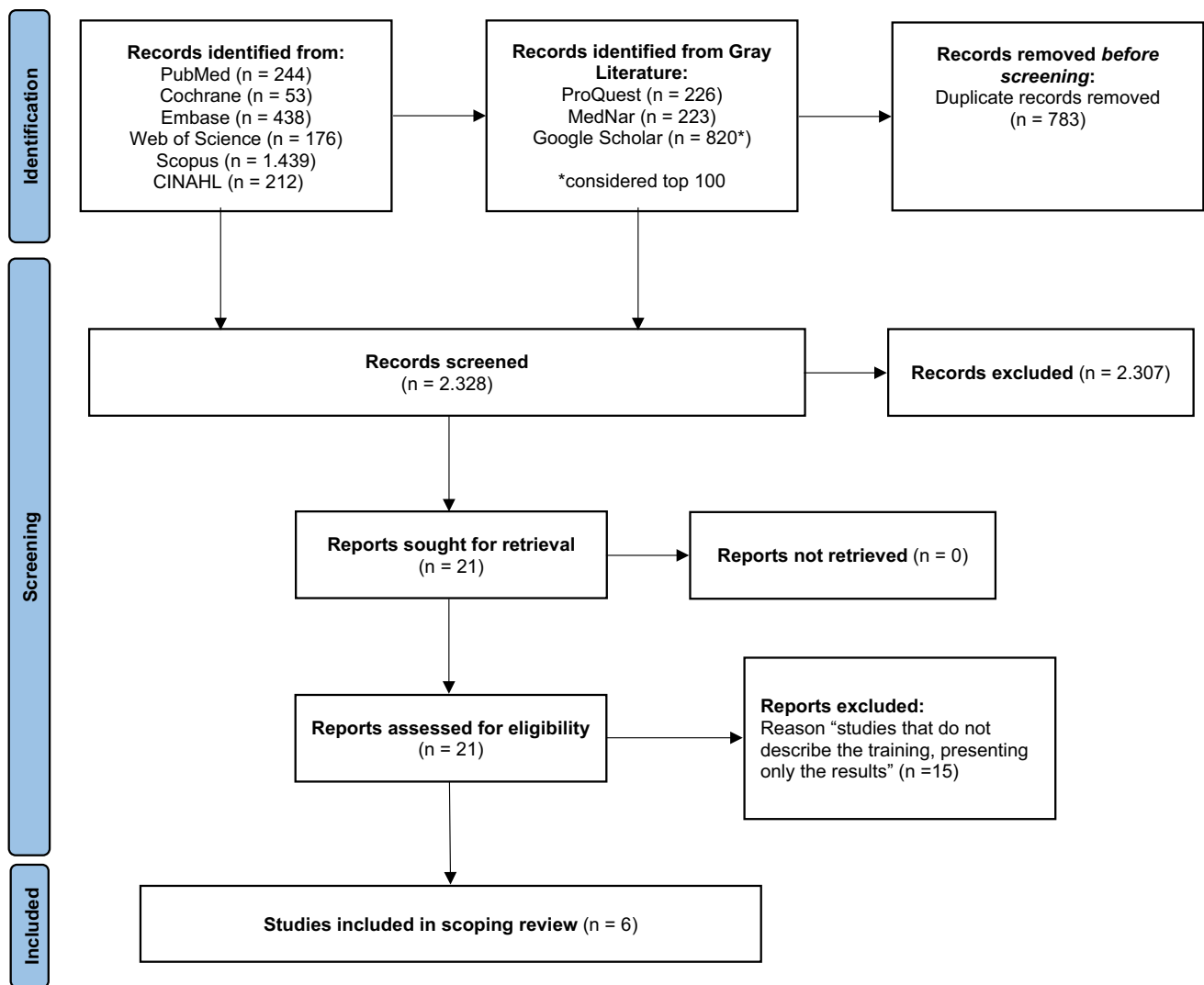[a]*FEES* fiberoptic endoscopic evaluation of swallowing

Fig. 1 PRISMA flowchart

for full-text reading and analysis considering the eligibility criteria, leaving six articles in the final sample. The study selection process results are detailed in the PRISMA flowchart [20] (Fig. 1).

The six articles that met the inclusion/exclusion criteria considered for this review are summarized in Table 2.

Characteristics of Studies

The studies were published between 2009 and 2022, with intervals of 2 to 4 years between 2009 and 2019 and smaller intervals of 1 to 2 years between 2019 and 2022. Three of the articles were conducted in the United States [12, 21, 22]; two in Germany [9, 23] and one in partnership between researchers from the United States and New Zealand [7].

In general, the studies aimed to present or validate scales developed for the functional assessment of swallowing,

mostly pharyngeal residue parameters [7, 21–23], penetration/aspiration [9] or both [7] only one study evaluated laryngeal sensitivity [12]. The places where the studies were carried out varied between hospitals, medical centers, an online platform, and universities, the latter being predominant.

Training Members Characteristics

Eligible studies considered one or more experts to perform reference classifications. Thirteen reference specialists and 99 participants analyzed swallowing parameters in the included studies (Table 3). There was significant heterogeneity in terms of years of experience for both specialists (5 to 27 years) and training participants (no experience and approximately 8 years of experience) (Table 3).

Table 2 General information on eligible studies

Author	Year/country	Study location	Objective
Warnecke et al. [9]	2009/DE	Hospital	To assess whether a previously established FEES[a] protocol based on the identification of findings indicative of stroke-related dysphagia can be learned and adopted by inexperienced clinicians
Kaneoka et al. [21]	2013/USA	University	Examine the reliability and validity of the Boston Residue and Clearance Scale (BRACS)
Neubauer et al. [22]	2015/USA	University	Develop, standardize, and obtain evidence of the validity of the Yale Pharyngeal Residue Severity Rating Scale (YPRSRS)
Gerschke et al. [23]	2019/DE	Online platform	Validate the German Version of the Yale Pharyngeal Residue Severity Rating Scale (YPRSRS) and investigate the impact of rater experience and training
Borders et al. [12]	2020/USA	Medical Center	To examine the inter- and intra-rater reliability of clinical classifications of the laryngeal adductor reflex (LAR) during the laryngeal sensation test with the touch method
Curtis et al. [7]	2022/USA & NZ	University	To describe the development of Visual Analysis of Swallowing Efficiency and Safety (VASES) and explore the feasibility of training novices to interpret FEES[a] using VASES

[a]*FEES* fiberoptic endoscopic evaluation of swallowing

Training Structure

Regarding the training presentation, there was high variability in the eligible studies. One study considered the presentation of a 30-min instructional lecture on swallowing physiology and specific aspects of the rating scale used [9], while another study performed a single training session that was divided into five parts, including a presentation of the scale rules, classification practice, video presentation with training examples and live group discussion between participants and experts [7]. This study had an average training time of 6 h (minimum of 4 h; maximum of 20 h). The other studies offered training that varied from a single session with an 8-min video tutorial [23] to two sessions of approximately 2 h [12]. One study did not mention training duration [22].

The characteristics of the exams that were presented to consider the participant's classification in the training also varied, ranging from 24 [9] to 125 videos [12]. To validate assessment instruments, some studies chose to use images for classification instead of video clips [22, 23]. The selection of tests considered samples that varied between consistency categories [9], severity levels in the swallowing parameters [21, 22], location of the evaluated parameter [23], and different diagnoses [9, 21] (Table 4).

Outcome Measures

Most studies considered intra- and inter-examiner reliability analysis as outcome measures. In some cases, reliability was the only measure used to assess participant competence [12, 22, 23]. Two studies considered the accuracy of the participants' ratings over the experts' [7, 9]. Only the study by Kaneoka et al. [21] established a criterion to assess whether the participant was trained enough to perform the analysis (Table 5).

Discussion

This scoping review aimed to identify and map all the available evidence on visual-perceptual skills training to analyze functional swallowing parameters obtained by FEES in

Table 3 Characteristics of training members in studies

Study	Specialists (N)	FEES[a] experience of specialist(s)	Participants (N)	FEES[a] experience of participants
Warnecke et al. [9]	2	NI	17	Inexperienced
Kaneoka et al. [21]	1	≥ 5 years	4	≥ 5 years
Neubauer et al. [22]	2	26 years	20	≅ 8 years
Gerschke et al. [23]	2	27 years	28	≥ 1 years
Borders et al. [12]	NI	NI	4	NI
Curtis et al. [7]	6	NI	26	Inexperienced

[a]*FEES* fiberoptic endoscopic evaluation of swallowing, *NI* not informed

Table 4 Training in eligible studies

	Warnecke et al. [9]	Kaneoka et al. [21]	Neubauer et al. [22]	Gerschke et al. [23]	Borders et al. [12]	Curtis et al. [7]
Swallowing parameters	Penetration/aspiration	Pharyngeal residues	Pharyngeal residues	Pharyngeal residues	Laryngeal sensitivity	Pharyngeal residues and penetration/aspiration
Training structure	Part (1) Instructional—30-min lecture on swallowing physiology and FEES[a]. Explanation and definition of the scale findings; Demonstration of characteristic videos. Part (2) Classification of video sequences, followed by a brief review of the videos and discussion (interactive teaching). Part (3) Classification of eight key sequences of complete exams for evaluation	3-h training session. The participants performed the examination classification independently and compared it to the specialist classification. If there was a discrepancy in the score, training continued. If there was a discrepancy in scoring, the training continued. When the score of the 4 raters and the specialist were within a range of 3 points on the total BRACS[b] score, the concordance was accepted and the 4 raters were deemed proficient	One-step training that included: written definitions, visual representations, verbal explanations, and clarifying questions/answers about the rating system. The study did not report training duration	Eight-minute video tutorial, including an audiovisual introduction to the concept of scales, representations, descriptions of severity levels, and image classifications exercises. No images used in the main experiment were used in training	Two sessions of approximately 2 h each. Reviewers developed rating guidelines for participants to judge 50 videos individually. After watching the video, the first author guided the discussions, and disagreements were resolved by consensus	Training in five parts: (1) Presentation of rules and operational definitions; (2) Practice rating five videos; (3) 60-min video; (4) Practice rating five videos; (5) 60-min live group session with discussion with one of the experts
Exam Characteristics	Part (1) does not apply. Part (2) 16 sequences of FEES[a] exams, divided into four samples of each category: secretion, puree, liquid, and semi-solid. Part (3) Eight sequences of complete examinations derived from three patients with left middle cerebral artery (MCA) infarction, three with right MCA infarction, and two with brainstem infarction	The study does not report the characteristics and quantity of videos used in training. In the experiment after training, 63 FEES[a] exams from 51 patients were used, with different underlying pathologies and severity levels of pharyngeal residues	It does not report the characteristics of the images used in training. In the main experiment, 25 images were used, one specimen without residue and three specimens from each of the four scale levels for vallecula and piriform sinuses	It does not report the characteristics of the images used in training. In the main experiment, 30 images were used, 15 of valleculae and 15 of piriform sinuses	Fifty videos were selected for the training session. The main experiment used 125 videos to analyze pre- and post-training reliability	Thirty-five videos of FEES[a] exams, 10 of which were repeated to allow an analysis of intra-evaluator reliability

[a] *FEES* fiberoptic endoscopic evaluation of swallowing
[b] *BRACS* Boston Residue and Clearance Scale

adults. Key questions included the training methods, what functional parameters were considered, the training-related diagnostic accuracy indicators, and the characteristics and contents of the training.

This scoping review found few studies on the training of individuals to assess FEES functional parameters. Regarding the years of publication, three articles were published in the last 3 years [7, 12, 23], while the other ones are from 7 to 12 years ago [9, 21, 22]—which reflects the lack of consistency in publications on this topic, and at the same time, an increase in interest. In the last 3 years, the interval between the publications of studies on training to analyze FEES parameters has decreased.

The training in the present study aimed to improve the reliability of the evaluation of professionals who use the new evaluation method. Surveys were carried out in institutions where FEES is commonly performed, such as hospitals, universities, medical centers, and workplaces of different professionals who manage dysphagia, where they usually meet to discuss clinical cases and develop research. Furthermore, a study was carried out on an online platform [23], which demonstrates the possibility of carrying out training using computational resources.

All studies aimed to present or validate scales developed for evaluating swallowing parameters, mostly pharyngeal residue parameters, penetration/aspiration, or both—only one study assessed laryngeal sensitivity [12]. Laryngeal sensitivity is strongly related to swallowing safety, since sensory impairment in the laryngeal area decreases airway protection, allowing the aspiration of liquid/food or oropharyngeal secretions [24, 25] and has been frequently associated with the occurrence of pharyngeal residues and inefficiency in the elimination of these residues [26]. Therefore, we included this parameter in this study.

The presence of pharyngeal residues in valleculae or pyriform sinuses after swallowing is related to swallowing inefficiency [27] and even predict the occurrence of laryngotracheal aspiration [28]. The parameter that investigates the occurrence of laryngeal penetration or laryngotracheal aspiration is closely related to swallowing safety because it assesses the severity of a significant event of an invasion of the airways and, therefore, has excellent clinical and research value [29].

The included studies considered the specialists as reference standards. Regarding the panel of experts, most had one or two specialists with at least 1 year of experience. Only the study by Curtis et al. [7] describes a more discerning consensus panel with certified professionals who have published research involving FEES performance and interpretation and obtained dysphagia education and clinical training in different national and international locations.

The number of participants ranged from 4 to 28 evaluators with different experiences. Some studies consider the experience in the execution and interpretation of the FEES [12, 21, 23], while others focused on participants without specific training for the analysis of the exam [7, 9]. These characteristics suggest that some classification scales are designed for clinical use by specialists, and others have a broader scope, which suggests their use by inexperienced health professionals if there is instruction or training to classify the parameters. Directing the practice to student participants, as done in the study by Curtis et al. [7], can provide a reasonably homogeneous group without the influence of the participants' experience on the results [30].

The training types in the studies involved didactic teaching, independent practical assessment, and blended approaches. Instructional training with lectures, video tutorials, written, visual, and verbal representations, and discussions with reference raters. All these were typical and generally increased the accuracy and reliability of outcome measures [7, 9, 21, 22]. Only one study was concerned with establishing a performance criterion to assess the evaluator's competence during training [21]. Professionals had their scores compared with the specialist, and they were considered proficient only when the scores were within a range of 3 points in the total score of the classification tool in the three swallowing consistencies evaluated.

Table 5 Outcome measures of studies

Study	Criteria for assessing competence	Measures related to training		
		Intra-examiner reliability	Inter-examiner reliability	Accuracy of classifications
Warnecke et al. [9]	NI	NI	NI	x
Kaneoka et al. [21]	x	NI	NI	NI
Neubauer et al. [22]	x	x	x	NI
Gerschke et al. [23]	x	NI	x	NI
Borders et al. [12]	x	x	x	NI
Curtis et al. [7]	x	x	x	x

NI not informed

There is no consensus on the number of hours suitable for the efficient training of professionals. While some studies carried out 2 to 3 h of training [12, 21], another study used the self-report of those trained to account for the average number of 6 h (minimum of 4 h, maximum of 20 h). More research is needed to determine the optimal training dose to achieve evaluator competence and reliability, particularly for inexperienced professionals. Previous academic and clinical experience may be associated with better performance or not at all influence the training results.

Most studies considered classifications through sequences of video clips or the complete exam [7, 9, 12, 21], while others used image frame analysis to evaluate [22, 23]. As FEES is a dynamic exam, this analysis usually takes place through videos in real conditions. However, many studies consider an analysis of frames for training purposes to obtain control of the internal validity of the research and comparisons between examiners. In any case, the examination by the isolated condition is still common in the clinical classifications of the exam. The number of tests evaluated in the studies has high variability, between 24 and 125 [9, 12].

Regarding the variables considered, most studies were limited to analyzing intra- and inter-evaluator reliability for the tool classification measures. Some information that would be useful to assess the effectiveness of the training was not mentioned, such as interest, knowledge about anatomy and physiology, and clinical experience of the participant, as Logemann [31] suggested in a study on training with videofluoroscopic swallowing exams. There were also no reports of self-confidence and analysis-related measures such as accuracy and speed, as well as how these variables relate to each other over training time. Furthermore, in the proposed scales, there is no possibility of doubts in the judgments and, therefore, the inability to work with uncertainties.

Inter-rater reliability analyses, often described in studies as outcome measures, bring us uncertain data. With inter-rater analysis, it is impossible to distinguish whether there was an increase in the accuracy of the classifications with training or whether the results of the novice raters influenced each other for an assessment prone to error. Future studies should take care when evaluating the accuracy of the classification, considering the opinions of qualified experts.

The acquisition of skills to perform FEES has been recommended worldwide. In some countries, institutions have developed structured and certified training curricula for this purpose [10, 32–34]. The intention is to establish best practice guidelines for professionals who perform and interpret FEES findings, including identifying functional swallowing parameters [33]. Although these international recommendations are intended to guide professional practice and establish better standards of care in dysphagia, they are more focused on the practical skills of FEES, such as inserting the endoscope through the nose. Training programs consider the importance of identifying and classifying functional parameters but do not describe how training should be or inform the required performance level for participants.

This scoping review identified, therefore, a knowledge gap, as the published and unpublished literature does not present specific results on training, being limited to training as a secondary objective in the validation studies of scales for the classification of these parameters. Many included articles were not explicit in the training description, with essential information often omitted or implied. In addition, they did not have as their primary objective the accomplishment of the training.

Our findings suggest the emerging need to develop structured and standardized training methods, considering variables that may influence the certification of competence of students and health professionals in analyzing FEES parameters. These methodologies must consider aspects such as the learning curve, performance report, difficulty levels for evaluating the images, skill levels, and progress, and using computational methods for the answers, offering immediate feedback to the participant.

Limitations

This review has some limitations, which may have impacted the results. Between the search for studies and the completion of this review, some recently published studies may have been lost. However, an update to this report in the coming years will provide an opportunity to include any studies that may have been missed. A second limitation of this review is our focus only on the functional parameters of swallowing, which excludes the assessment of anatomy through FEES. We sought to explore the functional capacity of swallowing, considering the pharyngeal and laryngeal sensory-motor assessment and saliva and food bolus management. Future studies should consider the anatomical evaluation, which also causes significant impacts on swallowing function.

Conclusion

Training to analyze FEES functional parameters is not standardized and is poorly described. The reviewed literature points to the need to develop training on visual-perceptual analysis of FEES to make students and health professionals who treat dysphagia competent for diagnosis. It is still relevant to study the variables that may influence participants' performance in training.

Declarations

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Bianca O. I. Costa MSc

Liliane S. Machado PhD

Milena M. Augusto MSc

Desiré D. D. Magalhães MSc

Thaís Coelho Alves PhD

Leandro Pernambuco PhD