

Supraglottic adjustments in contemporary singing: a scoping review

Ajustes supraglóticos no canto
contemporâneo: revisão de escopo

Ajustes supraglóticos en el canto
contemporáneo: revisión de alcance

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Abstract

Introduction: Contemporary singing, in its popular and crossover forms, is characterized by the use of supraglottic adjustments that influence vocal aesthetics, projection, and health. These mechanisms—such as epilaryngeal narrowing, anteroposterior and mediolateral compressions, and pharyngeal constrictions—differentiate musical styles and have been increasingly investigated in Vocal Pedagogy and Speech-Language Pathology, although the literature presents significant methodological heterogeneity. **Objective:** To map, through a scoping review, the available evidence on supraglottic adjustments employed by popular and crossover singers in contemporary singing. **Method:** The search was conducted in April 2025, covering publications from 1992 to 2024, in the MEDLINE, EMBASE, LILACS, Scopus, Web of Science, and Cochrane databases, as well as in gray literature (Google Scholar, MedRxiv, and ProQuest). Controlled and uncontrolled descriptors in English and Portuguese, related to “singers” and “vocal adjustments,” were used. Primary studies and systematic reviews addressing supraglottic adjustments in popular and crossover singers, professional or amateur, were included. Exclusion criteria comprised studies limited to classical singers or focusing on glottic, subglottic, or psychoacoustic adjustments, as

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well as theoretical essays, editorials, and commentaries. Two independent reviewers performed screening and data extraction. **Results:** A total of 28 studies were included, mostly empirical and experimental, with variability in design and musical styles. The most frequent adjustments were epilaryngeal narrowing, anteroposterior and mediolateral laryngeal compressions, and pharyngeal constrictions, described across different vocal techniques and cultural traditions. **Conclusion:** The evidence indicates that supraglottic adjustments are key determinants of vocal production in contemporary singing, playing an essential role in sound projection, stylistic differentiation, and physiological adaptation to acoustic demands. Despite methodological heterogeneity, a consensus emerges regarding their importance for understanding performance, training, and vocal health in popular and crossover singers.

Keywords: Voice; Singing; Music; Speech-Language and Hearing Sciences; Scoping Review.

Resumo

Introdução: o canto contemporâneo, nas vertentes popular e *crossover*, caracteriza-se pelo uso de ajustes supraglóticos que influenciam a estética, a projeção e a saúde vocal. Esses mecanismos – como estreitamento epilaringeo, compressões anteroposterior e mediolateral e constrictões faríngeas – diferenciam estilos musicais e têm sido cada vez mais investigados na Pedagogia Vocal e na Fonoaudiologia, embora a literatura apresente considerável heterogeneidade metodológica. **Objetivo:** mapear, por meio de uma revisão de escopo, as evidências disponíveis sobre os ajustes supraglóticos empregados por cantores populares e *crossover* no canto contemporâneo. **Método:** a busca foi realizada em abril de 2025, com abrangência de publicações entre 1992 e 2024, nas bases MEDLINE, EMBASE, LILACS, Scopus, Web of Science e Cochrane, além da literatura cinzenta (Google Scholar, MedRxiv e ProQuest). Foram utilizados descritores controlados e não controlados em português e inglês, relacionados a “cantores” e “ajustes vocais”. Foram incluídos estudos primários e revisões sistemáticas sobre ajustes supraglóticos em cantores populares e *crossover*, profissionais ou amadores, e excluídos trabalhos restritos a cantores líricos, a ajustes glóticos, infraglóticos ou psicoacústicos, além de ensaios teóricos, editoriais e comentários. Dois revisores independentes realizaram triagem e extração dos dados. **Resultados:** foram incluídos 28 estudos, majoritariamente empíricos e experimentais, com variabilidade quanto ao delineamento e aos estilos musicais. Os ajustes mais recorrentes foram o estreitamento epilaringeo, as compressões anteroposterior e mediolateral da laringe e as constrictões faríngeas, descritos em diferentes técnicas e tradições vocais. **Conclusão:** as evidências indicaram que os ajustes supraglóticos são determinantes para a produção vocal no canto contemporâneo. Estes desempenham um papel essencial na projeção sonora, diferenciação estilística e adaptação fisiológica às demandas acústicas. Apesar da heterogeneidade metodológica, observa-se um consenso quanto à relevância desses ajustes para compreender a performance, o treinamento e a saúde vocal de cantores populares e *crossover*.

Palavras-chave: Voz; Canto; Música; Fonoaudiologia; Revisão de Escopo.

Resumen

Introducción: El canto contemporáneo, en sus vertientes popular y *crossover*, se caracteriza por el uso de ajustes supraglóticos que influyen en la estética, la proyección y la salud vocal. Estos mecanismos –como el estrechamiento epilaringeo, las compresiones anteroposterior y mediolateral y las constricciones faríngeas– diferencian los estilos musicales y han sido cada vez más investigados en la Pedagogía Vocal y la Fonoaudiología, aunque la literatura presenta una notable heterogeneidad metodológica. **Objetivo:** Mapear, mediante una revisión de alcance, la evidencia disponible sobre los ajustes supraglóticos empleados por cantantes populares y *crossover* en el canto contemporáneo. **Método:** La búsqueda se realizó en abril de 2025, abarcando publicaciones entre 1992 y 2024, en las bases de datos MEDLINE, EMBASE, LILACS, Scopus, Web of Science y Cochrane, además de literatura gris (Google Scholar, MedRxiv y ProQuest). Se emplearon descriptores controlados y no controlados en inglés y portugués, relacionados con “cantantes” y “ajustes vocales”. Se incluyeron estudios primarios y revisiones sistemáticas sobre ajustes supraglóticos en cantantes populares y *crossover*, profesionales o aficionados. Se excluyeron investigaciones centradas exclusivamente en cantantes líricos o en ajustes

glóticos, infraglóticos o psicoacústicos, así como ensayos teóricos, editoriales y comentarios. Dos revisores independientes realizaron la selección y extracción de los datos. **Resultados:** Se incluyeron 28 estudios, en su mayoría empíricos y experimentales, con variabilidad en el diseño y los estilos musicales. Los ajustes más frecuentes fueron el estrechamiento epilaríngeo, las compresiones anteroposterior y mediolateral de la laringe y las constricciones faríngeas, descritos en diversas técnicas vocales y tradiciones culturales. **Conclusión:** La evidencia indica que los ajustes supraglóticos son determinantes en la producción vocal del canto contemporáneo, desempeñando un papel esencial en la proyección sonora, la diferenciación estilística y la adaptación fisiológica a las demandas acústicas. A pesar de la heterogeneidad metodológica, existe consenso sobre su relevancia para comprender el rendimiento, la formación y la salud vocal de los cantantes populares y *crossover*.

Palabras clave: Voz; Canto; Música; Patología del Habla y Lenguaje; Revisión de Alcance.

Introduction

Singing is a universal practice across different cultures and musical styles and has been the subject of increasing scientific interest due to its physiological and aesthetic complexity. Sung vocal production results from the interaction among infraglottic, glottic, and supraglottic mechanisms, with the latter playing a fundamental role in resonance modulation, vocal projection, and stylistic differentiation across musical genres.^{1,2}

In popular and contemporary musical genres—often described in opposition to classical singing—there is a wide diversity of vocal techniques that involve distinct configurations of the vocal tract. Styles such as rock, pop, jazz, soul, gospel, musical theater, fado, overtone singing, khoomei, and kargyraa are recurrently investigated because they represent expressive acoustic and physiological contrasts between Western and non-Western repertoires. These genres exemplify different forms of supraglottic compression, constriction, and adjustment, allowing for a deeper understanding of the versatility of the human vocal tract across varied stylistic contexts.^{3,7} This selection is based on comparative studies that describe, for example, anteroposterior and mediolateral compressions associated with rock and belting,^{2,8,9} pharyngeal and vocal tract adjustments in fado,⁴ and phenomena of biphonation and formant clustering in traditional styles such as khoomei and overtone singing.^{5,6}

Comparative studies indicate that styles such as belting and rock involve higher subglottic pressures, greater glottal adduction, and intense supraglottic compressions, frequently associated with vocal projection and stylistic identity.^{8,10} In contrast, classical singing and the so-called neutral

mode, according to Complete Vocal Technique (CVT), tend to favor more open and less extreme supraglottic adjustments, with stabilized resonance and reduced laryngeal compression.¹¹

Despite advances in research on the physiology of singing and source-filter interactions, the field of singing voice research remains characterized by high conceptual, terminological, and methodological heterogeneity, in addition to encompassing a wide diversity of practices and musical genres. This breadth may hinder the organization and synthesis of available knowledge regarding supraglottic adjustments in specific vocal-use contexts.

Although relevant literature on the singing voice exists, a preliminary search of review protocol repositories—MEDLINE, the Cochrane Database of Systematic Reviews, and JBI Evidence Synthesis—did not identify recent scoping or systematic reviews that specifically address non-classical singers within this conceptual framework.

The absence of a structured synthesis focused on this topic contributes to the dispersion of available evidence and limits the possibility of an integrated view of the different approaches, musical styles, and methodological designs described in the literature. This observation does not imply an absolute knowledge gap nor presuppose the identification of consistent patterns, but rather indicates the lack, to date, of reviews that systematically map and describe the existing body of evidence.

In this context, conducting a scoping review is appropriate to identify, map, and characterize the existing scientific production on supraglottic adjustments in non-classical singers, as well as to describe the types of available evidence, the methods employed, and the main conceptual focuses addressed. It is therefore expected to contribute

to the organization of knowledge, support professional practice in speech-language pathology and vocal pedagogy, and inform the design of future investigations in the field of sung voice.

Thus, the objective of this study was to map, through a scoping review, the available evidence on supraglottic adjustments employed by popular and contemporary singers. The term *crossover* is used only when explicitly mentioned in primary sources, referring to singers who move between popular and classical repertoires, without constituting the main focus of the analyzed sample.

Methods

This scoping review was conducted in accordance with the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) and the Joanna Briggs Institute Reviewer's Manual.^{12,14} The protocol was registered on the Open Science Framework (OSF) platform under DOI 10.17605/OSF.IO/P4KCE on January 20, 2025.

Methodological Approach and Research Question

The research question was developed based on the Population, Concept, and Context (PCC) framework, in accordance with the Joanna Briggs Institute (JBI) guidelines. The population of interest comprised popular and contemporary singers, professional or amateur, including Western and non-Western styles that do not fall within the classical or operatic category. The concept addressed was supraglottic adjustments, defined as structural and functional modifications above the glottis—such as epilaryngeal narrowing, anteroposterior and mediolateral supraglottic compression, pharyngeal constrictions, and modulations of oral and labial openings—observed during sung vocal production. The context of analysis included vocal practices related to contemporary singing, covering studies of performance, training, and physiological and acoustic assessment. Based on these elements, the guiding question was established: “What supra-

glottic adjustments are described in the scientific literature in popular and contemporary singers?” The term *crossover* was retained only when used in primary sources to designate singers who move between popular and classical repertoires and does not constitute an independent focus group.

Eligibility Criteria

Primary studies (observational, experimental, clinical trials, or case studies) and systematic reviews describing supraglottic adjustments in popular or contemporary singers were included. Eligible studies were published between 1992 and 2024, in Portuguese or English, and presented empirical quantitative or qualitative data on vocal tract configuration, as well as acoustic, aerodynamic, perceptual, or imaging analyses. Studies focused exclusively on classical or operatic singers, research centered solely on glottic, infraglottic, or psychoacoustic adjustments, and theoretical texts, editorials, letters, or comments without original data were excluded. The language restriction (Portuguese and English) is justified by the broader coverage of international databases in these languages and the limited availability of relevant repositories in other languages for this specific topic.

Information Sources and Search Strategy

The electronic search was conducted in April 2025 across six citation and abstract databases: Latin American and Caribbean Health Sciences Literature (LILACS), Medical Literature Analysis and Retrieval System Online (MEDLINE), EMBASE, Web of Science, Scopus, and Cochrane. A grey literature search was also performed in January 2025 using Google Scholar, MedRxiv, and ProQuest. Additionally, a citation search was conducted within the reference lists of the included articles to identify further relevant studies not captured in the database searches. The search strategies were developed using both indexed and free-text terms based on the PCC framework. Combinations of descriptors related to singers (e.g., “singing”) and vocal adjustments (e.g., “voice,” “voice quality”) were applied using Boolean operators (AND, OR) and truncation. The search was restricted to Eng-

Chart 1. Search Strategies in the Databases

Database	Date	Search Strategy	Number of Articles
MEDLINE/ PUBMED	April/2025	("singing"[mesh] OR "singer"[tiab] OR "singers"[tiab] OR "vocalist"[tiab] OR "performer"[tiab] OR "lead singer"[tiab] OR "vocal performer"[tiab]) AND ("voice"[mesh] OR "voice qualities"[tiab] OR "voices"[tiab] OR "voice acoustics"[tiab] OR "vocal acoustics"[tiab] OR "voice spectrum"[tiab] OR "phonatory parameters"[tiab] OR "voice parameters"[tiab] OR "vocal parameters"[tiab] OR "singing voice quality"[tiab] OR "voice resonance"[tiab])	1277
EMBASE	April/2025	('singing'/exp OR 'singer':ti,ab,kw OR 'singers':ti,ab,kw OR 'vocalist':ti,ab,kw OR 'performer':ti,ab,kw OR 'lead singer':ti,ab,kw OR 'vocal performer':ti,ab,kw) AND ('voice'/exp OR 'voice qualities':ti,ab,kw OR 'voices':ti,ab,kw OR 'voice acoustics':ti,ab,kw OR 'vocal acoustics':ti,ab,kw OR 'voice spectrum':ti,ab,kw OR 'phonatory parameters':ti,ab,kw OR 'voice parameters':ti,ab,kw OR 'vocal parameters':ti,ab,kw OR 'singing voice quality':ti,ab,kw OR 'voice resonance':ti,ab,kw)	1670
LILACS	April/2025	((mh:(singing) OR tw:(singer OR singers OR vocalist OR performer OR lead singer OR vocal performer))) AND ((mh:(voice) OR tw:(voice qualities OR voices OR voice acoustics OR vocal acoustics OR voice spectrum OR phonatory parameters OR voice parameters OR vocal parameters OR singing voice quality OR voice resonance)))	83
SCOPUS	April/2025	(((INDEXTERMS (singing)) OR (TITLE-ABS-KEY (singer OR singers OR vocalist OR performer OR lead singer OR vocal performer))) AND ((INDEXTERMS (voice)) OR (TITLE-ABS-KEY (voice qualities OR voices OR voice acoustics OR vocal acoustics OR voice spectrum OR phonatory parameters OR voice parameters OR vocal parameters OR singing voice quality OR voice resonance))))	5660
Web of science	April/2025	((TS=(singer OR singers OR vocalist OR performer OR lead singer OR vocal performer)) AND (TS=(voice qualities OR voices OR voice acoustics OR vocal acoustics OR voice spectrum OR phonatory parameters OR voice parameters OR vocal parameters OR singing voice quality OR voice resonance)))	660
Cochrane	April/2025	#1 MeSH descriptor: [singing] #2 singer:ti,ab,kw OR singers:ti,ab,kw OR vocalist:ti,ab,kw OR performer:ti,ab,kw OR lead singer:ti,ab,kw OR vocal performer:ti,ab,kw #3 #1 OR #2 #4 MeSH descriptor: [voice] #5 voice qualities:ti,ab,kw OR voices:ti,ab,kw OR voice acoustics:ti,ab,kw OR vocal acoustics:ti,ab,kw OR voice spectrum:ti,ab,kw OR phonatory parameters:ti,ab,kw OR voice parameters:ti,ab,kw OR vocal parameters:ti,ab,kw OR singing voice quality:ti,ab,kw OR voice resonance:ti,ab,kw #6 #4 OR #5 #7 #3 AND #6	22

Chart 2. Grey Literature Search Strategy

Grey Literature	Date	Search Strategy	Number of Articles
ProQuest	April/2025	("singing") AND ("voice")	100
MedRxiv	April/2025	("singing") AND ("voice")	134
Google Scholar	April/2025	("singing") AND ("voice")	100

lish due to the broader coverage of international databases for the topic under investigation. The complete search strategy for each database is detailed in Charts 1 and 2.

Study Selection

Study selection was carried out in four stages: (1) reviewer calibration; (2) title and abstract screening; (3) duplicate removal; and (4) full-text assessment of eligible articles (complete texts reading).

During the calibration stage, conducted in January 2025, a pilot search was performed in the MEDLINE/PubMed and LILACS databases to test the application of the eligibility criteria and standardize the screening process. Two reviewers independently analyzed a sample of 83 records, and Cohen's kappa coefficient was calculated to assess inter-rater agreement. A minimum value of 0.7 was established as the threshold to proceed to the main screening phase.

After calibration, the complete search was conducted in April 2025 across the MEDLINE/PubMed, EMBASE, LILACS, Scopus, Web of Science, and Cochrane Library databases, in addition to a complementary grey literature search (Google Scholar, MedRxiv, and ProQuest). Duplicate records were automatically removed using the Rayyan platform, and subsequent screening was performed independently by two reviewers.

In the initial screening, inclusion criteria were applied based on titles and abstracts. Potentially eligible studies were then assessed in full, applying the exclusion criteria. Disagreements between reviewers were resolved by a third researcher, who performed the final arbitration.

Data Extraction and Charting

Data extraction was conducted in a standardized manner by two independent reviewers using electronic spreadsheets (Microsoft Excel). The extracted variables included author, year, and country of publication; methodological design; study objective; sample size and characteristics (sex, age range, race/ethnicity); investigated musical styles; vocal classification; type of supraglottic adjustment described; evaluation protocols employed; and the main results and conclusions reported by the authors.

Data synthesis was performed through descriptive and quantitative analysis, including the calculation of absolute and relative frequencies of the extracted variables. No critical appraisal of study methodological quality was conducted, as recommended for scoping reviews.¹² The results were organized into tables and graphically represented using word clouds, distribution charts, and geographic maps, when applicable. The present approach allowed for mapping the breadth and diversity of the available evidence, identifying thematic trends, methodological gaps, and recurring patterns in the literature on supraglottic adjustments in contemporary singing.

Results

The search strategy across the databases retrieved 1,362 records, of which 628 remained after duplicate removal using the automation tools of the Rayyan platform and manual exclusion of ineligible records. During the title and abstract screening stage, 39 publications were deemed eligible for full-text assessment. Following full-text reading, 11 studies were excluded, resulting in 28 publications included in the synthesis (Figure 1).

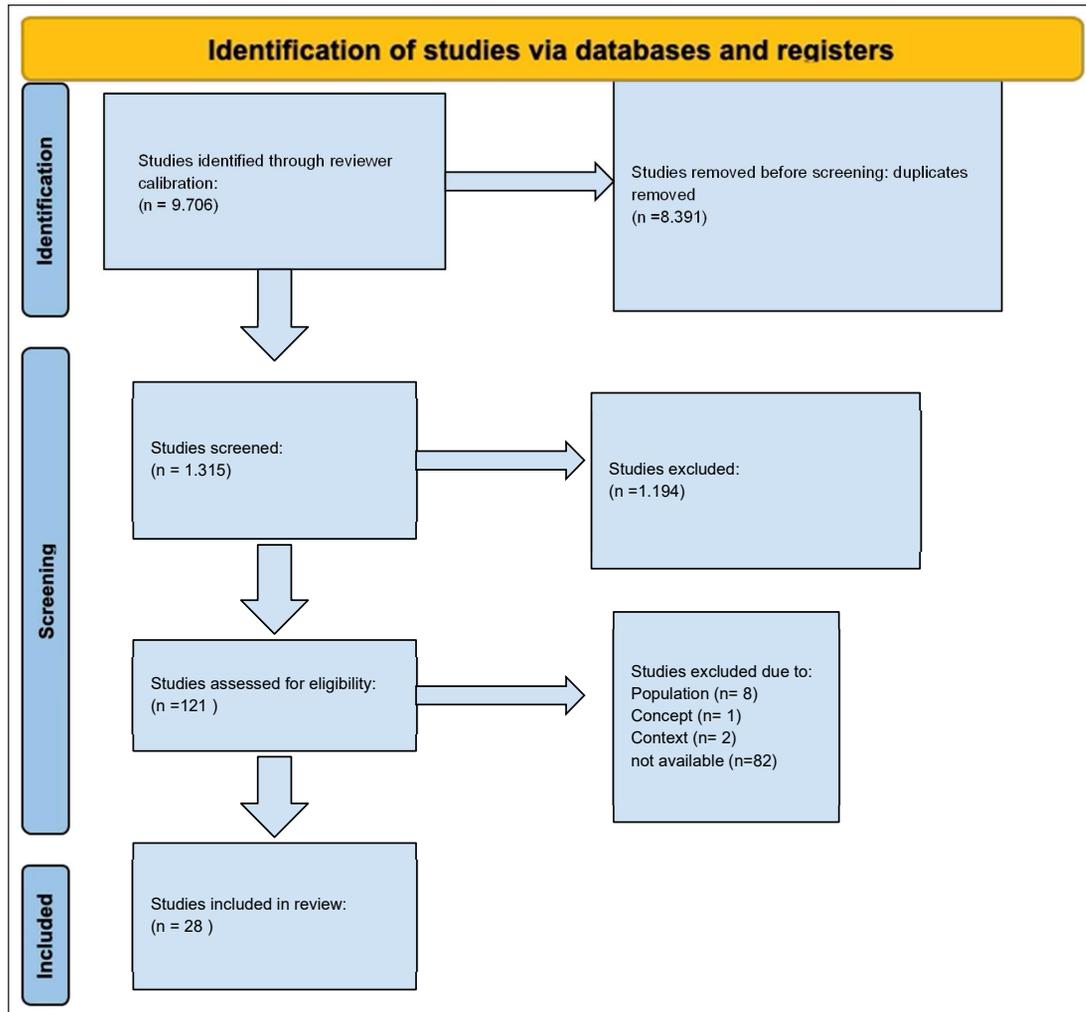


Figure 1. PRISMA 2020 Flow Diagram (Page et al., 2021)

Characteristics of the Present Study

A total of 28 studies were included in the review, with publications spanning from 1992 to 2024, showing peaks in 2015 ($n = 3$), 2020 ($n = 3$), 2021 ($n = 3$), and 2023 ($n = 3$). Regarding the studies' countries of origin, the United States

($n = 6$), Sweden ($n = 5$), and Chile ($n = 3$) predominated (Figure 1). Other countries represented were Canada, the Netherlands, Portugal, China, Norway, Germany, Brazil, the United Kingdom, Denmark, Austria, Lebanon, Finland, and Spain (Chart 3).

Chart 3. Characteristics of the included studies: author(s), year, country of publication, study design, sample, musical genre, supraglottic adjustments, and assessment method.

Author(s) (Year)	Country	Study Design	Sample	Musical Genre	Supraglottic Adjustments	Assessment Method
Hallqvist et al. (2016)	Portugal	Experimental	6 professional singers	Soul, musical theater	↑ subglottic pressure, greater glottal adduction	Inverse filtering, acoustic analysis
Saldías et al. (2020)	Chile	Experimental case study	1 singer	High twang (CCM)	Epilaryngeal narrowing, pharyngeal constriction	Tomography, acoustic, perceptual
Bottalico et al. (2019)	USA	Cross-sectional observational	14 female singers (21–58 years)	Opera, belting	Relationship between palate dimensions and supraglottic adjustments	Acoustic analysis (SPR, A2/A1)
Saldías et al. (2018)	Chile	Cross-sectional observational	5 subjects (4 dysphonic, 1 singer)	Belting / hyperfunctional dysphonia	High larynx, narrow epilaryngeal outlet, hypopharyngeal narrowing	Computed tomography
Santoni et al. (2018)	Canada	Experimental (auditory feedback)	30 (20 men, 10 women)	Not specified	Nasal/oral balance (no specific adjustments detailed)	Nasometer, auditory feedback
Wu et al. (2021)	China e USA	Longitudinal (training)	17 singing students	Vocal training	Anteroposterior and mediolateral compression	Stroboscopy, aerodynamic
Sundberg e Skoog (1996)	Sweden	Experimental	10 professional singers	Operatic and popular	Mandibular opening as a supraglottic adjustment	Acoustic analysis, F1 analysis
Laeng, Kuyateh e Kelkar (2021)	Norway	Experimental (audiovisual integration)	Not reported	Musical intervals (Indian classical and Western)	Facial/labial movements influence perception	Audiovisual clips, perceptual evaluation
Sundberg, Lindblom e Hefele (2023)	Germany	Experimental case study	1 singer	Overtone singing	Clustering of F2 and F3, labial opening	Acoustic analysis, dynamic MRI
Fadel et al. (2015)	Brazil	Cross-sectional observational	60 amateur female singers	Metallic voice (sertanejo/country)	Elevated formant frequencies (F2–F4), shortened vocal tract	Acoustic analysis
Bergevin et al. (2020)	USA e Canada	Experimental (MRI + acoustics)	4 Tuvan singers	Khoomei (biphonic singing)	Alveolar + uvular constriction, harmonic focus	Dynamic MRI, acoustic analysis
Miller e Schutte (1993)	Netherlands	Pilot physiological study	2 female singers	Flageolet register	Specific laryngeal and supraglottic movements	EGG, acoustic
Aaen et al. (2024)	United Kingdom e Denmark	Experimental (EGG + acoustics)	32 professional singers	Extreme vocal effects	Supraglottic structures activated	EGG, acoustic
Lebowitz e Baken (2009)	USA	Observational	5 professional female singers	Belting vs. legit	Strong glottal adduction, associated supraglottic adjustments	EGG, LTAS
Schutte e Miller (1993)	Netherlands	Preliminary comparative	Not reported	Belting and non-classical	Laryngeal position and supraglottic adjustments	Spectrum analysis, EGG
Zangger-Borch e Sundberg (2011)	Sweden	Experimental	1 professional singer	Rock, Pop, Soul, Swedish Dance Band	↑ subglottic pressure, variable supraglottic adjustments	Inverse filtering, acoustic

Author(s) (Year)	Country	Study Design	Sample	Musical Genre	Supraglottic Adjustments	Assessment Method
Sundberg, Thalén e Popeil (2012)	Sweden e USA	Experimental	1 female singer	Belting substyles	Minimal supraglottic variation	Acoustic, perceptual
Mendes, Rodrigues e Guerreiro (2012)	Portugal	Cross-sectional observational	15 singers	Fado	Vibrato present, no singer's formant	Acoustic (MPT, jitter, shimmer, HNR)
Guzman et al. (2015)	Chile	Cross-sectional observational	12 female singers (mean age 27 years)	Pop, Rock, Jazz	A-P, medial and pharyngeal compression, VLP	Videolaryngoscopy, LTAS
Sundberg e Thalén (2015)	Sweden	Experimental	6 female singers	Belting vs. neutral	↑ glottal adduction, ↑ supraglottic compression	Plethysmography, acoustic, SPL
Lindestad et al. (2001)	Sweden	Experimental	1 singer	Kargyraa	Ventricular fold vibration at half vocal fold frequency	High-speed imaging, EGG, acoustic
Carlsson e Sundberg (1992)	Sweden	Experimental	Not reported	Formant tuning	F1 and F2 tuning near harmonics	Acoustic
Hamdan et al. (2008)	Lebanon	Cross-sectional observational	13 singers	Middle Eastern singing	Piriform sinus and supraglottic resonance adjustments	Real-time spectrogram
Erickson (2003)	USA	Experimental	Not reported	Vocal classification	Mandibular opening related to formant frequency	Auditory perception
Sundberg et al. (2017)	Sweden e Denmark	Experimental	2 singers	Overdrive (CVT)	Elevated larynx, $F1 \approx 2f_0$, moderate compression	EGG, acoustic
Leppävuori et al. (2020)	Finland	Experimental (MRI)	4 singers	CVT modes	Edge = maximal narrowing; Neutral = less open mouth	MRI, auditory
Herbst, Story e Meyer (2023)	USA e Austria	Experimental/ acoustic	Not reported	Belting	Systematic vowel modification	Acoustic analysis, modeling
Sundberg, Lã e Granqvist (2023)	Sweden e Portugal	Experimental	9 singers	Tube glissandos	Supraglottic modulation of f_0 instability	Acoustic, spectrography

Regarding study design, 18 studies were experimental or quasi-experimental, with evaluation criteria based on acoustic, aerodynamic, or videolaryngoscopic analysis of vocal emissions.^{2,3,6,17} Eight additional studies were observational or descriptive, and two consisted of systematic or narrative reviews related to vocal physiology.^{8,9} Sample sizes ranged from 1 to 82 participants, including professional singers and singing students, with females predominating in approximately 60% of the publications (Chart 3).^{3,5,10}

The most frequently studied musical styles were rock, pop, belting, musical theater, gospel, and jazz, followed by traditional styles such as fado, overtone singing, and khoomei.^{3,7,9,11} This stylistic diversity reflects the growing interest in understanding phonatory and resonant variations between Western and non-Western repertoires, which involve distinct supraglottic adjustments and produce different acoustic patterns (Chart 3).^{4,6,7,10,11}

Among the most frequently reported supraglottic adjustments were epilaryngeal narrowing,^{15,16} anteroposterior and mediolateral laryngeal supraglottic compressions,^{3,6,17} and pharyngeal constrictions.^{4,8} These adjustments have been described as strategies to enhance vocal efficiency, project sound, and reinforce upper resonance formants, specifically the third and fourth formants (F3–F4), with a direct impact on timbre and acoustic power (Chart 3).^{5,6,17,18}

Studies on belting and rock^{3,5,9,16,18} demonstrated patterns of intense epilaryngeal compression and upper pharyngeal narrowing, associated with vocal emissions involving high subglottic pressure and a bright timbre. In contrast, research on the neutral mode (neutral mode, according to CVT)^{11,17,19} reported a more open supraglottic configuration with less constriction. In traditional styles repertoires, such as khoomei and overtone singing, phenomena of biphonation and formant clustering (formant tuning) were observed, with precise control of the epilaryngeal and pharyngeal cavities (Chart 3).^{7,10,11}

Overall, the results indicate that supraglottic adjustments represent recurrent and multifunctional physiological mechanisms, whose occurrence varies according to musical style, type of vocal training, and the acoustic demands involved. Despite advances in research in singing voice, many studies exhibit incomplete or heterogeneous descriptions of the methodological procedures employed, including limited information on sample characteristics, selection criteria, evaluation instruments, and analysis parameters. Furthermore, terminological and conceptual variability is evident in the description of supraglottic phenomena, along with inconsistencies in the integration of acoustic, aerodynamic, and physiological measures (Chart 4).^{3,5,6,9,11,17}

Chart 4. Characteristics of the studies, including author(s), year, main results, and conclusions.

Author(s), Year	Main Results	Conclusion
Hallqvist et al. (2016)	Soul = \uparrow subglottic pressure, greater flow declination, lower Sound Pressure Level (SPL).	Small differences, but soul shows greater laryngeal resistance than musical theater.
Saldías et al. (2020)	High twang = epilaryngeal narrowing and pharyngeal constriction.	High singing similar to accent requires distinct vocal tract adjustments.
Bottalico et al. (2019)	Palate dimensions influenced Singing Power Ratio (SPR) and A2/A1.	Physiological structure impacts vocal production and styles (opera, belting).
Saldías et al. (2018)	Belting and dysphonia share high larynx and pharyngeal narrowing.	Belting differs from dysphonia by greater oral/labial opening (megaphone shape).
Santoni et al. (2018)	Altered auditory feedback did not change nasalance in singers/non-singers.	Oral-nasal control does not depend on vocal training.
Wu et al. (2021)	Training reduced A-P compression and \uparrow MPT.	Vocal training modulates supraglottic adjustments and improves efficiency.
Sundberg e Skoog (1996)	Mandibular opening \uparrow with pitch height, especially /a/ and /æ/.	Biomechanical strategy to align F1 with f_0 at high pitches.
Laeng et al. (2021)	Facial movements altered perception of intervals.	Supraglottic configuration also influences audiovisual perception.
Sundberg et al. (2023)	Overtone singing = F2-F3 clustering regulated by tongue and lips.	Phenomenon explained by the source-filter model, without an additional source.
Fadel et al. (2015)	Metallic voice = normal F0, \uparrow F2-F4.	Style associated with shortened vocal tract and hyperfunctional supraglottic adjustments.
Bergevin et al. (2020)	Khoomei = alveolar and uvular constrictions, focus on overtones 1.5-2 kHz.	Biphonation results from precise supraglottic modulation.
Miller e Schutte (1993)	Flageolet register showed distinct vocal patterns.	Pedagogically recognized but lacks objective definition.
Aaen et al. (2024)	Extreme effects altered acoustic spectrum without affecting EGG (except grunt/creaking).	Effects can be produced in a healthy manner, with supraglottic adjustments.
Lebowitz e Baken (2009)	Belting = SQ and CQ distinct from legit.	Chest voice has its own physiological signature.
Schutte e Miller (1993)	Pop/belting \neq classical in laryngeal adjustments.	Chest/pop voice is physiologically distinct from classical voice.
Zangger-Borch e Sundberg (2011)	Rock showed higher Psub and SPL; Dance Band, the lowest.	Styles differ by subglottic pressure and resonance.
Sundberg et al. (2012)	Belting substyles varied in glottal source; formants were little differentiated.	Vocal source is determinant for differentiating substyles.
Mendes et al. (2012)	Fado = \uparrow jitter/shimmer, absence of singer's formant.	Cultural style with vibrato, but less projected technique.
Guzman et al. (2015)	Rock = greater A-P, medial, and pharyngeal compression.	Intense supraglottic adjustments may be protective, not pathological.
Sundberg e Thalén (2015)	Belting = \uparrow Psub, SPL, and adduction; no respiratory differences.	Belting depends on laryngeal adjustments, not respiratory pattern.
Lindestad et al. (2001)	Kargyraa = ventricular folds vibrate at $f_0/2$.	Guttural voice results from vocal fold-ventricular fold interaction.
Carlsson e Sundberg (1992)	Adjustment of F1/F2 to harmonics alters timbre and intensity.	Formant tuning is not universally applicable.
Hamdan et al. (2008)	Middle Eastern singing: speech \times singing differences in F1-F3, no singer's formant.	Cultural style without the typical Western classical formant cluster.
Erickson (2003)	Formant frequency influenced perception of vocal category.	Listeners use supraglottic cues to classify voices.
Sundberg et al. (2017)	Overdrive = high Psub, $F1 \approx 2f_0$, strong adduction.	Mode defined by specific supraglottic and acoustic adjustments.
Leppävuori et al. (2020)	Edge = maximal narrowing; Neutral = less open mouth.	CVT modes differ by supraglottic geometry.
Herbst et al. (2023)	Belting requires systematic vowel modifications.	Belting depends on vowel adjustments, not only glottal settings.
Sundberg et al. (2023)	Tube glissandos: breaks occur when harmonics coincide with resonances.	Supraglottic/resonatorial adjustments reduce instability.

Discussion

The results of this review reinforce that supraglottic adjustments play a central role in stylistic differentiation and vocal projection, being frequently described as functional strategies involved in the organization of sound production across different musical contexts.^{3,7,9,11,15} However, the relationship of these adjustments with vocal health is neither direct nor univocal and should be interpreted in light of the demands imposed by the musical style, the singer's level of training, and the adaptive strategies employed.

Studies on popular singing styles, such as rock, pop, and belting, indicate that these repertoires involve intense supraglottic adjustments, including supraglottic anteroposterior compression, supraglottic mediolateral compression, and pharyngeal narrowing.^{3,5,9,16,18} These configurations are frequently associated with elevated subglottic pressures, as increased supraglottic resistance requires greater airflow and pressure to maintain stable glottic vibration and acoustic efficiency.^{15,16,20} This increase in subglottic pressure should not, in itself, be interpreted as indicative of hyperfunction or vocal risk, but rather as a context-dependent adaptive mechanism that can enhance sound projection and vocal economy when properly coordinated and trained.^{5,17,18}

Specific musical traditions, such as *khomei*, *kargyraa*, overtone singing, *fado*, and Middle Eastern singing, demonstrate that the principles of supraglottic manipulation are universal, yet adapted to distinct cultural and aesthetic contexts.^{7,10,11,23,27} In overtone singing, for example, clustering of the second and third formants (F2–F3) creates selective reinforcement of harmonics, whereas in *khomei* and *kargyraa*, biphonation arises from the combined constriction of supraglottic cavities, highlighting the plasticity of the human vocal tract in meeting stylistic and cultural demands.^{7,25,26}

Studies on vocal intervention and training confirm that supraglottic activity is modulable and can be reduced or adjusted with pedagogical guidance.^{17,28} This indicates that vocal training influences not only glottic patterns but also supraglottic coordination, promoting more economical and stable vocal emissions.

Evidence on source–filter interactions indicates that supraglottic adjustments not only differentiate vocal styles but also stabilize phonation by modi-

fying vocal tract impedance, thereby preventing register breaks and optimizing resonance and sound projection.^{15,23,24,27} Classical physiological studies^{15,16,19} have already demonstrated that epilaryngeal narrowing enhances source–filter coupling, intensifying formant bands and promoting vocal radiation—a principle that contemporary pedagogical practices (e.g., CVT, Estill Voice Training) consciously apply as a stylistic resource.^{11,19,30}

The literature^{3,5,9,16,29,30} confirms that popular styles such as belting and loud *twang* mobilize complex supraglottic adjustments, including epilaryngeal narrowing, anteroposterior and mediolateral supraglottic compressions, and upper pharyngeal constrictions. Although these configurations may be interpreted as hyperfunctional in a clinical context, in singing they function as biomechanical adaptive strategies that enhance vocal emission efficiency, allowing greater projection with lower perceived effort.^{5,9,18} These findings underscore that belting and other non-classical singing styles exhibit distinctive physiology, characterized by greater glottal adduction, laryngeal elevation, and supraglottic compression, representing specific techniques rather than mere stylistic variations.^{5,11,18,30}

Thus, supraglottic adjustments emerge as a central framework for understanding vocal performance across diverse musical genres, integrating aspects of sound projection, stylistic identity, and pedagogical adaptation.^{3,7,9,11,15,18}

Limitations

Several limitations should be acknowledged in the present study. Despite conducting searches across multiple databases and in the grey literature, it is possible that relevant studies were not identified, particularly those not indexed in conventional databases or published in languages other than English and Portuguese. Additionally, marked methodological heterogeneity was observed among the included studies, with wide variation in study designs, sample sizes—from single-case studies to larger cohorts—investigated musical styles, and assessment procedures employed.

Regarding assessment methods, a variety of approaches were identified, including acoustic, perceptual-auditory, aerodynamic, endoscopic, and imaging analyses. It is noteworthy that, in the specific field of vocal tract analysis, there is a scarcity of widely adopted, systematized protocols, with the model proposed by Duprat (2014), based

on imaging assessment, representing one of the few attempts to provide a descriptive framework of these adjustments.

This diversity of approaches, coupled with the lack of uniformity in data collection and analysis procedures, precludes direct quantitative comparisons or meta-analyses, limiting the findings of the present review to a narrative and descriptive synthesis. These limitations underscore the complexity of the field and highlight the need for greater methodological clarity and more detailed reporting of the procedures in future investigations on supraglottic adjustments in singing.

Furthermore, many studies^{3,7,9,11,15,18} did not report sociodemographic data (e.g., age, gender, race/ethnicity) or detailed information on the level of vocal training, which restricts the generalizability of the findings and the understanding of the influence of individual factors on supraglottic adjustments. Finally, variation in methodological quality and the lack of standardization of instruments were observed; therefore, the evidence presented in the present study should be interpreted as an exploratory mapping of the field rather than as definitive conclusions.

Conclusion

The present scoping review mapped the available scientific evidence on supraglottic adjustments in sung vocal production, encompassing popular singing styles, extreme techniques, and musical traditions from diverse cultural backgrounds.

The findings demonstrated that supraglottic adjustments—including epilaryngeal narrowing, anteroposterior and mediolateral compressions, pharyngeal constrictions, and modulations of mandibular and supraglottic opening—are fundamental components of stylistic differentiation and vocal projection, also serving as mechanisms of physiological adaptation to the acoustic demands of each style.

In popular and contemporary repertoires, such as rock, pop, and belting, these adjustments occur in a more intense and controlled manner, reflecting biomechanical strategies of vocal efficiency aimed at maximizing sound radiation and preserving the integrity of the vocal folds under high subglottic pressure. Consequently, configurations that might be interpreted as hyperfunctional in clinical con-

texts appear, in singing, to exert a protective and stabilizing function on phonation.

Investigations of cultural traditions, such as fado, khoomei, kargyraa, and overtone singing, corroborate that, despite stylistic differences, phonatory principles adhere the source–filter model, in which supraglottic adjustments modulate resonance and define the sonic identity of each tradition.

Therefore, supraglottic adjustments should be understood as universal and multifunctional physiological elements that integrate stylistic identity, projection, and vocal health, constituting a central framework in the understanding of contemporary sung voice.

It should be noted, however, that the literature exhibits significant methodological heterogeneity, including small samples, variability in assessment protocols, and gaps in demographic and objective data. Consequently, future research should focus on standardizing assessment methods and the integrating of acoustic, physiological, and perceptual measures to advance understanding of the relationship between glottic and supraglottic adjustments and their impact on sung vocal quality.

Declaration of conflicts of interest

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