



Voice and vocal tract of wind instrumentalists: Integrative literature review

Voz e trato vocal de instrumentistas de sopro: Revisão integrativa da literatura

Voz y tracto vocal de instrumentistas de sopro: Revisión integrativa de literatura

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Abstract

Objective: To perform an integrative review of the literature on the voice and characteristics of the vocal tract of wind instrumentalists in order to compare the findings of such studies and better understand the possible vocal risks to which these musicians may be exposed. **Methodology:** A search was performed in the following databases SciELO, LILACS, PubMed and Google Scholar. The articles were selected based on the inclusion and exclusion criteria, the studies were checked as suitable to the researched topic, only studies available in Portuguese, English or Spanish were selected, further the title and the abstract of the selected articles were analyzed. The research was: What are the characteristics of voice and vocal tract configurations of wind instrumentalists? **Results:** Seven articles were selected to compose the sample of the present review. The full text of the selected articles was read and their data were organized and cataloged. **Conclusion:** Wind instrumentalists had voice qualities with more tension and instability than non-instrumentalists, and had discrete voice deviations. The vocal folds are medialized while the instrument is being played. Separate wind instrument categories should be studied so that the influence of this practice on the vocal tract can be better explored.

Keywords: Voice; Voice quality; Acoustics; Music.

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Authors' contributions:

ACAMG: Study idealization. Data analysis. Writing and editing of the paper.

IMCAG: Data collection, paper writing and formatting.

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Resumo

Objetivos: Realizar uma revisão integrativa da literatura sobre a voz e características do trato vocal de instrumentistas de sopro, a fim de comparar achados de tais estudos e melhor compreender os eventuais riscos vocais a que esses músicos possam estar expostos. **Metodologia:** Foram pesquisados artigos publicados nas bases de dados SciELO, LILACS, PubMed e Google Acadêmico. Os artigos foram selecionados com base nos critérios de inclusão e exclusão, sendo verificada a adequação ao tema pesquisado, estar disponível em Português, inglês ou espanhol, após isso os artigos pré-selecionados passaram por uma análise de seu título e resumo para verificar se seriam utilizados na presente revisão. A questão norteadora que compôs a primeira etapa da pesquisa teve como abordagem a seguinte questão: *Quais as características da voz e configurações do trato vocal de instrumentistas de sopro?* **Resultados:** Foram selecionados sete artigos para compor a amostra da presente revisão. Os artigos selecionados foram lidos integralmente e seus dados foram organizados e catalogados. **Conclusão:** Com relação à qualidade vocal, os instrumentistas apresentaram maiores níveis de tensão e instabilidade quando comparados a não instrumentistas de sopro, e desvio vocal discreto. Há medialização das pregas vocais durante a execução do instrumento. É necessário estudar, separadamente, as categorias distintas de instrumentistas de sopro, a fim de melhor conhecer os efeitos específicos dessa prática no trato vocal.

Palavras-chave: Voz; Qualidade da voz; Acústica; Música.

Resumen

Objetivos: Realizar una revisión integrativa de la literatura sobre la voz y características del tracto vocal de instrumentistas de sopro, para comparar hallazgos de tales estudios y comprender mejor los eventuales riesgos vocales a que estos músicos puedan eventualmente estar expuestos. **Metodología:** Se han investigado artículos publicados en las bases de datos SciELO, LILACS, PubMed y Google Académico, seleccionados por criterios de inclusión y exclusión, disponibles en portugués, inglés o español. Fue verificada la adecuación al tema. Los artículos pre seleccionados pasaron por análisis de título y resumen para verificar si serían utilizados en esta revisión. La cuestión orientadora que compuso la primera etapa de la investigación fue: *¿Cuáles son las características de la voz y configuraciones del trato vocal de instrumentistas de sopro?* **Resultados:** Se seleccionaron siete artículos para componer la muestra de la presente revisión. Los artículos seleccionados fueron leídos íntegramente y sus datos fueron organizados y catalogados. **Conclusión:** Con respecto a la calidad vocal, los instrumentistas presentaron niveles más altos de tensión e inestabilidad en comparación con los no instrumentistas del viento y una desviación vocal discreta. Hay medialización de las cuerdas vocales durante la ejecución del instrumento. Las categorías distintas de instrumentistas de sopro deberán ser estudiadas en separado, para que el efecto de esa practica em el tracto vocal sea mejor explorada y conocida.

Palabras clave: Voz; Calidad de la voz; Acústica; Música.

Introduction

Wind instruments are classified as brass – when sound is produced by the direct vibration of the lips on the metal mouthpiece, and woodwinds – when sound is produced by the air passing inside the mouthpiece which makes the reed(s) in the mouthpiece vibrate while the pulmonary airstream passes through it¹.

The larynx plays an active part in sound production in these types of instruments, and control of both the airflow and the blowing itself is related to the alternation between glottal constriction and opening².

Studies show that vocal fold adduction may be the greatest cause of technique difficulties during the execution of Wind instruments, related to glottal and supraglottal tension while playing the instrument. This tension acts to control the player's airflow. In addition, during this process, the vocal folds do not close completely but keep an intermediate position during sound production in the instrument and the articulation of musical notes, whatever the type of wind instrument has active laryngeal participation³⁻⁵.

For a long time, it was believed that the vocal folds did not play an active role in sound production of wind instruments, and the effort of the respiratory and oromandibular muscles would bear the sole responsibility for this function. Since the vocal tract is intensely used in sound production, that the air blown may be turned into sound and is related to instrument playing techniques and, considering the frequency of instrument execution, the act of playing a Wind instrument may be a demanding activity on the larynx, leading to disorders in glottal configuration that may lead to dysphonia or to voice complaints^{2,5}.

When Speech-Language Pathologists and Audiologists study musicians, they generally focus on singers or in hearing conservation of musicians. Wind instrumentalists constitute a group that needs to be studied in more detail, due to the intense participation of the larynx and vocal folds during instrument execution. Considering this fact and that few studies have proposed to study and to assess laryngeal participation in sound production of wind instruments, there is a need to better understand the role of the vocal tract in the production of this specific sound.

Some literature reviews focusing on wind instrumentalists were previously conducted⁶. The work mainly focuses on players' vocal behavior and eventual voice symptoms. However, it is believed that, in order to better understand the mechanism involved in any voice complaints of wind instrument players, it is very important to study vocal tract behavior during this activity and, then, the eventual consequences on these individuals' phonatory mechanisms.

Therefore, the purpose of this study is to conduct a literature review on the voice quality and vocal tract characteristics of Wind instrumentalists, in order to compare the findings in literature and, thus, better understand the potential vocal risks to which these musicians may be exposed.

Material and method

An integrative literature review is a rigorous research method that aims to produce scientific knowledge in a certain field. This method synthesizes data from theoretical and empirical studies, increasing the broadness of information on a specific topic and approximating results to their clinical applications⁷.

This review was conducted between August and October, 2017, when scientific papers, undergraduate theses, abstracts in proceedings, masters' dissertations and doctoral theses were consulted and selected after searches in online data bases.

There was no limit on time of publication for selected papers.

In order to conduct this review, scientific papers in three languages – Portuguese, English and Spanish - were surveyed in the following data bases: LILACS (Latin American and Caribbean Health Sciences Literature); SciELO (Scientific Electronic Library Online), PubMed and Google Scholar.

The guiding question that composed the first step of the search was: *“What are the voice characteristics and vocal tract configurations of wind instrument players?”*

Based on this guiding question, the following key words were defined for the search: “voz”, “trato vocal”, “instrumento de soprano”, “instrumentista de soprano”; in Portuguese. Their correspondents in English: “voice”, “vocal tract”, “wind instruments”, “wind instrumentalists”; and

Spanish: “voz”, “tracto vocal”, “Instrumento de viento”, “instrumentista de soplo”.

In order to contemplate the proposed themes, the boolean operators “or” and “and”, were used, in accordance to the *Medical Subject Headings/* Descritores em Ciências da Saúde (MESH/DECS).

The inclusion criteria for the studies were original papers and literature reviews (as this is not a systematic review study), that had results regarding the voice and vocal tract of wind instrument players, as well as theses and proceedings published in Portuguese, English or Spanish.

After the search in the data bases, the findings were assessed based on title and abstract of the studies and those that did not meet the inclusion criteria were excluded. The selected studies were

fully read in order to complete the subsequent steps. Those that, after a full text reading did not answer the guiding question, or those that were duplicated among data bases were excluded

Results

The search yielded 1452 results from the consulted data bases, and seven studies were selected to compose the final sample of this research. Table 1 shows the results of study selection according to data base. Again, the studies that did not answer the guiding question or that were duplicated among the bases were excluded.

The studies selected to compose the present review were fully read and their data were organized.

Table 1. Search results according to data base

DATA BASE	NUMBER OF STUDIES	STUDIES EXCLUDED FOR NOT MEETING INCLUSION CRITERIA	STUDIES EXCLUDED FOR BEING DUPLICATED	SELECTED STUDIES
SCIELO	35	33	1	1
LILACS	518	517	1	0
PUBMED	890	886	1	3
GOOGLE SCHOLAR	9	6	0	3
TOTAL	1452	1442	3	7

Chart I. Data of the studies that compose the review

TITLE	LAN-GUAGE	COUN-TRY	AUTHOR	YEAR	TYPE OF STU-DY – DESIGN	PURPOSE	SAMPLE	ASSESSMENT METHOD	CONCLUSION	DATA BASE
Configuração glótica em tocadores de instrumento de sopro	Portuguese	Brazil	Eckley CA	2006	Article – Cross-sectional	To evaluate the laryngeal and vocal tract behavior of musicians who play Wind instruments	10 wind instrument players	Videolaryngoscopy and questionnaire	The glottis plays an active role in the sound production of Wind instruments and disorders in glottal configuration may interfere in the final production of sound.	Scielo
Vocal Tract Discomfort and Voice-Related Quality of Life in Wind Instrumentalists	English	Brazil	Cappellaro J; Beber BC	2017	Article – Cross-sectional	To investigate vocal tract discomfort and quality of life of wind instrument players	37 wind instrument players	Questionnaire	The symptoms of vocal discomfort were seldom present in wind instrument players. They occur more frequently in musicians who have been for less time in the orchestra.	PubMed
Vocal fold polyp in a professional brass/Wind instrumentalists and singer	English	USA	Gallivan GJ; Eitnier CM	2006	Article – Case study	Undisclosed	1 wind instrument player	Videolaryngoscopy	The glottis controls the airflow and affects sound quality. However, the study concludes that laryngeal configurations do not derive from playing the instrument, but from other activities performed by the studied musician.	PubMed
Lateral laryngopharyngeal diverticula: a videofluoroscopic study of laryngopharyngeal wall in wind-instrumentalists	English	Brazil	Costa MMB; Alvite FL	2012	Article – Cross-sectional	To identified possible diverticulum formations in the laryngopharyngeal wall produced by pharyngeal overpressure during wind instrument playing	22 wind instrument players	Videofluoroscopy	Laryngopharyngeal diverticula are a consequence of pharyngeal overpressure.	PubMed
Avaliação da qualidade vocal de militares instrumentistas de sopro da banda de música da polícia militar do Paraná e comparação antes e após ensaio	Portuguese	Brazil	Ferreira APS	2010	Masters' Dissertation – Cross-sectional	To evaluate the vocal profile of military Wind instrumentalists playing in the Military Police band of the state of Paraná and to analyze the immediate effect of rehearsal in these players' vocal quality	25 wind instrument players and 28 non-wind instrument players	Questionnaire, perceptive auditory analysis and acoustic analysis.	The military wind instrument players have vocal symptoms such as voice breaks and weak voice. They have more breathy voices. There were no changes in the analyzed voice parameters in acoustic and perceptive auditory assessments after the rehearsal.	Google Scholar
Avaliação vocal e cervicoescapular em militares instrumentistas de sopro	Portuguese	Brazil	Silvério KCA, Pereira EC, Menonim LM, Dias CAS, Santos CLG, SchwartzmanPP	2010	Article – Cross-sectional	To evaluate the vocal quality, breathing and cervical-scapular region in wind instrument players of the musical band of the army	30 wind instrument players and 12 non-wind instrument players	Questionnaire and perceptive auditory analysis	The military wind instrument players had voice and muscle disorders and need vocal health promotion and postural guidance.	Google Scholar
Comportamento vocal em músicos de sopro: uma revisão de literatura	Portuguese	Brazil	Falchetti AC	2014	Undergraduate thesis – Literature review	To conduct a literature review that will describe the laryngeal behavior of wind instrument players while they play and possible voice disorders.	PubMed, Google Acadêmico, Liliacs and Scielo Data bases	6 studies	wind instrument players may have voice complaints that are related to instrument use that may be associated to inadequate vocal habits and lack of vocal hygiene.	Google Scholar

Discussion

The voice is produced in the vocal tract from a sound that is generated in the larynx, a tubular structure composed of the hyoid bone, muscles and cartilages and where the vocal folds are located. The sound is produced by the vibration of the vocal folds and propagates through the vocal tract, composed by several cavities (larynx, pharynx, mouth, nose, sinuses) and other mobile structures (mandible, tongue, soft palate, lips) that, in resonance effect, amplify certain frequencies of the laryngeal sound, through their transfer function, shape the sound which, after the lips' radiation effect, consists of the sound of voice⁸.

The voice is understood to be the result of the interaction between the aerodynamic and myoelastic forces involved in phonation and the vocal tract's transfer function. Voice disorders may occur if there is an unbalance in this complex mechanism^{9,10}.

The studies that compose the present review^{2,5,6,10-13} agree that wind instrumentalists may have a wide range of health issues, such as laryngeal and voice disorders. However, Gallivan and Eitnier¹¹ say, in their paper, that there is more information about health problems caused by playing wind instruments in musical literature than in literature of the medical field which poses difficulties in obtaining studies on this topic. Eckley⁵ states that the fact that there are still few studies with this population occurs due to the historic notion that the vocal tract would not act directly in the sound production of the wind instrument, and that the effort for sound production would be made only by respiratory and oromandibular muscles, where the larynx would only need to be open to allow the passage of pulmonary air.

A vocal symptom is something that the individual reports feeling regarding his/her vocal characteristics¹⁴. Of the seven studies selected to compose this research, three used questionnaires^{2,5,9} to investigate symptoms, aiming to relate possible self-reported findings to playing wind instruments. Among the main vocal symptoms reported by these individuals are: phlegm, weak voice, sore throat, voice breaks, hoarseness and vocal discomfort after long periods of playing, in addition to dry throat, pain and irritability of the vocal tract. These symptoms may be explained by the voluminous airflow in the vocal tract and oral cavity during instrument

execution, which may lead to the dehydration of these structures¹⁵. According to Verdolini, Titze and Fennel¹⁶, hydration contributes to the organic and functional health of the larynx, since it provides the mucosa with the necessary elastic properties that are needed for favorable vibration conditions, less friction between the vocal folds and consequently, less exposure to mechanical trauma in this region. Players must be advised to keep hydrated in order to control the reported symptoms. Another possible explanation for the symptoms reported by the subjects in the studies in the high expiratory pressure when playing their instruments that may occur alongside inadequate vocal habits of the studied musicians. According to literature, high phonatory intensity and inadequate vocal habits are the most common vocal risks associated with the occurrence of these symptoms¹⁷.

Ferreira et al¹⁸ state that, in order to conduct an effective survey about certain professionals' vocal symptoms, endogenous and exogenous issues should be interrogated. In the studies that composed this sample, there were no questions regarding airway diseases and only one study¹³ assessed the vocal habits of these individuals. These were, most commonly: coughing, vocal strain in noisy environments, phlegm, "excess" coffee intake, and "insufficient" water consumption. Two papers^{2,13} used, in addition to questionnaires, auditory perceptible evaluation to assess the instrumentalists' voices. Perceptive auditory analysis is considered the gold standard of voice assessment and is still above other evaluation techniques, as it characterizes vocal quality and quantifies voice deviations¹⁹.

The study with the greatest number of subjects was the one by Cappellaro and Beber¹⁰ that included 37 wind instrumentalists, and the one with the least was a case study by Gallivan e Eitnier¹¹ of one not specified wind instrument player. Mean age varied between 23¹¹ and 42 years⁵.

The population studied was of male and female adults. When adding all of the individuals in the study, there is a total of 125, of which 113 were male and 12 female. Even though male participation in bands and orchestras seems to be larger (between 70 and 80%, approximately)^{20,21} it is important to note that only two studies^{5,10} have also included women players. Literature shows the influence of sex in the development of voice disorders, such as the fact that women are more predisposed to develop voice disorders since the

female glottal proportion is reduced when compared to males. Furthermore, women represent the majority of the population seeking clinical Speech Pathology intervention²². It is interesting though, that, even with these data, none of the studies that included women analyzed the voice and vocal tract data separately, according to sex.

Regarding study design, of the seven analyzed works, there were five cross-sectional studies^{2, 5, 10, 12, 13}, one case report¹¹ and one literature review⁶. Different clinical and instrumental methods of investigation were employed, such as: videolar-yngoscopy^{5, 11}, questionnaires^{2, 5, 10, 11}, perceptive auditory voice analysis^{2, 13}, acoustic analysis of the voice signal¹³ and videofluoroscopy¹². Furthermore, one study reviewed the literature in data bases, selecting six studies for analysis⁶.

Using videolar-yngoscopy, Eckley⁵ and Gal-livan and Eitinier¹¹ observed that the instruments' musical notes were produced during vocal fold adduction, and the airflow control was related to the alternation between glottal constriction and opening. It should also be noted that the control of airflow affected the quality of the sound that was produced by the instrument. Holmberg et al²³ explain that, with time, the effort in the glottal region during vocal fold adduction may increase muscle tension and subglottal pressure, which may lead to voice quality disorders and may come alongside different levels of turbulent noise.

The literature describes several scales that may be used for auditory perceptual analysis. Ferreira¹³ used a 100mm visual analogic scale, and describes that the voices of the 25 analyzed instrumentalists varied among 'normal' and mild disorders, with values between zero and 35.5 mm on the proposed scale. Data from an assessment performed with the GRBASI scale² showed that the studied Wind instrument players had greater problems in the tension and instability parameters than subjects who did not play wind instruments. The author also states that these instrumentalists may develop dys-phonia as these parameters indicate that the larynx is being used with effort. Studies show that vocal effort may cause an overload in laryngeal muscles, and individuals who constantly use their voices as a work tool are more predisposed to develop voice disorders. Among these, the most commonly found are vocal nodules and focal fold edemas²⁴.

One of the studies¹³ used the acoustic analysis of the subjects' voices in addition to questionnaires

and auditory perceptual analysis and suggested that the acoustic parameters of fundamental frequency, jitter, shimmer and Glottal Excitation Noise (GNE) measured in the instrumentalists' voice signals was within normal standards.

Finally, one study¹² performed a videofluoros-copy assessment and the findings showed a lateral pharyngeal diverticulum in all of the evaluated Wind instrumentalists, with variable progression areas. Trumpet and clarinet players had large and bilateral diverticula. Even though it is known that there are two large groups of wind instruments (woodwind and brass) and that they have acoustically different behaviors, the study does not analyze its findings considering this fact.

The hypothesis here is that, given the differ-ences in each instrument's sound source (lips, vi-bration of a single or double reed), material (wood or brass), geometry, among others, some instru-ments may require greater vocal effort during their execution than others^{9, 25}. In spite of the literature affirming that wind instruments are acoustically different and require different amounts of effort in their execution, none of the studies that were selected to compose this review separated the par-ticipating players by type or group of instrument. Assuming that these instruments are played while the vocal folds are medialized, The complex phys-ical mechanisms that cause differences in impedance along the vocal tract^{7, 26}, as well as the variations in sound source, material, shape, use of pulmonary airflow¹⁰, among other characteristics of the instru-ments could (in addition to intrinsic factors of the vocal tract of each player), influence, in different ways, the level of laryngeal effort during musical execution. This may, in turn, influence the percep-tion of vocal quality and vocal tract discomfort of the subjects.

One study conducted with 27 instrument play-ers²⁷ concluded that, in itself, the fact of playing a Wind instrument does not generally put one at risk for voice disorder. It may, however, cause adverse effects especially on the spoken voice, under certain conditions such as, for example, in case of pre-existing dysphonia.

Therefore, there is a need of studies that will separate musicians in groups according to the different types of Wind instruments, in order to analyze the differences in vocal tract configura-tion and possible vocal tract discomfort in voice symptoms that these musicians may have, aiming

to better explain the possible effects on the vocal tract that instruments with different acoustical properties may have. Thus, a specific approach considering the type of instrument that is played is extremely important and should be better explored in future studies.

Several occupational hazards in brass instrument players have been reported, such as muscle-skeletal problems, hearing loss, visual impairments, facial and dental anatomic disorders, cardiac arrhythmia, and swelling of the parotid gland²⁸, that may interfere with the overall health and professional career of these musicians. Wind instrument players intensely use the vocal tract in their profession, with specific adaptations to the different types of instruments may develop voice disorders, that affect the glottal source and/or the filter²⁹. Falchetti⁶ concludes her review stating that wind instrumentalists have voice complaints related to instrument execution, and these complaints may be associated to inadequate vocal habits and lack of vocal hygiene, and does not exclude the possibility that the complaints may also have different causes.

Therefore, it is important to conduct studies that focus on voice quality and vocal tract configuration of wind instrument players, in order to better assess the need for Speech-Language Pathology intervention with these professional, including vocal health information and vocal warm-up guidance.

Conclusion

Regarding voice quality, the Wind instrument players had more tension and instability when compared to people who do not play Wind instruments, in addition to discrete vocal quality deviation.

Considering the participation of the vocal tract in the execution of Wind instruments and the small number of studies in literature, there is a need for more studies that focus on these professionals' vocal tracts, since playing implies the use of a structural configuration of the voice production system that may influence their work activities and exposes the player to eventual voice complaints and disorders. It is known, however, that there is medialization of the vocal folds during instrument execution. Therefore, there may be need for specific guidance regarding vocal health maintenance due to the variety of symptoms reported by literature.

The vocal symptoms and vocal tract discomfort symptoms reported by the analyzed studies are:

phlegm, weak voice, sore throat, voice breaks, hoarseness, vocal discomfort, dryness, pain and irritability of the vocal tract.

Future studies that aim to understand the voice characteristics and vocal tract configuration of Wind instrument players may consider distinct groups, not only according to sex, but also to the types of Wind instruments (brass and woodwinds) in order to better describe the relation between playing the instrument and eventual discomfort symptoms that this practice may cause to the voice and vocal tract, considering the Wind instrumentalist a professional who uses the larynx as a tool for work and artistic expression.

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