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Trombone Breathing: An Empirical Study in Higher Music Education in the Valencian Community

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Abstract
Breathing is a fundamental yet conceptually diverse component of trombone pedagogy. This study investigates divergent respiratory conceptions and their observable manifestations in higher trombone education. A mixed-methods observational field study was conducted during the 2021–2022 and 2022–2023 academic years across the Higher Music Conservatoires of the Valencian Community, Spain. Data were collected through teacher interviews, pedagogical-document analysis, a student questionnaire, and audiovisual observation of instrumental practice. Results revealed three pedagogical orientations: Jacobs, associated with full-body breathing and *wind*; Ricquier, associated with abdominal breathing and pressure; and Individual or Other Approaches, encompassing alternative conceptions. Jacobs and Individual or Other Approaches showed the highest mean affinity scores (1.8 each), followed by Ricquier (1.4). Observational data identified increased muscular tension during ascent into the upper register, accompanied by deteriorating perceived sound quality. These findings highlight discrepancies between reported conceptions and observed performance behaviours.

Keywords: Trombone, Pedagogy, Breathing; Methodology, Music education.

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La respiración en el trombón: Estudio empírico en los Conservatorios Superiores de Música de la Comunidad Valenciana

Resumen

La respiración constituye un componente fundamental, aunque conceptualmente diverso, de la pedagogía del trombón. Este estudio investiga las concepciones respiratorias divergentes y sus manifestaciones observables en la enseñanza superior del trombón. Se llevó a cabo un estudio de campo observacional con metodología mixta durante los cursos académicos 2021–2022 y 2022–2023 en los Conservatorios Superiores de Música de la Comunidad Valenciana, España. Los datos se recopilaron mediante entrevistas a profesores, análisis de documentos pedagógicos, un cuestionario dirigido al alumnado y la observación audiovisual de la práctica instrumental. Los resultados revelaron tres orientaciones pedagógicas: Jacobs, asociada a la respiración completa y al concepto de *wind*; Ricquier, asociada a la respiración abdominal y a la presión; y Enfoques Individuales u Otros, que engloba concepciones alternativas. Jacobs y Enfoques Individuales u Otros mostraron las puntuaciones medias de afinidad más elevadas (1,8 cada una), seguidas de Ricquier (1,4). Los datos observacionales identificaron un aumento de la tensión muscular durante el ascenso hacia el registro agudo, acompañado de un deterioro de la calidad sonora percibida. Los resultados ponen de manifiesto discrepancias entre las concepciones declaradas y los comportamientos observados durante la interpretación.

Palabras clave: Trombón, Pedagogía, Respiración, Metodología, Educación musical.

Introduction

Breathing constitutes one of the most relevant technical and interpretive components in trombone instruction and, at the same time, one of the areas in which markedly different pedagogical conceptions can be found. In the preceding theoretical framework, approaches to breathing described in the specialized literature on the trombone and brass instruments by twenty-two authors were analysed and compared (Cotolí, 2025).

To analyse this diversity, a multidimensional analytical model was developed to compare the approaches of the main authors according to different parameters related to their pedagogical foundations and the implementation of breathing techniques. The dimensions considered included methodological orientation—procedural, interpretive, or complementary—the type of breathing advocated, and the conceptions underlying the control and support of the air column. Based on these indicators, three reference orientations were established: *Ricquier*, *Jacobs*, and *Individual or Other Approaches*.

The *Ricquier* and *Jacobs* approaches constitute the two most clearly differentiated pedagogical reference points. Ricquier (1982) proposes a predominantly procedural methodology based on abdominal breathing and his theory of ‘vertical pressure’. Its aim is to facilitate the understanding and management of the air during exhalation through the use of the ‘abdominal wall’, which functions as a form of support.

Jacobs combines procedural and interpretive approaches, providing theoretical knowledge while prioritizing musical intention. He advocates full-body breathing and the concept of ‘wind’. His approach is associated with the so-called ‘relaxed pressure curve’, which emphasises respiratory-system expansion and rib-cage elasticity as factors contributing to efficient airflow with minimal muscular effort (Frederiksen, 1996).

The following figure illustrates the conceptual contrast between the respiratory approaches associated with Ricquier and Jacobs. The terms shown represent pedagogical conceptions described in the literature and should not be interpreted as direct physiological measurements.

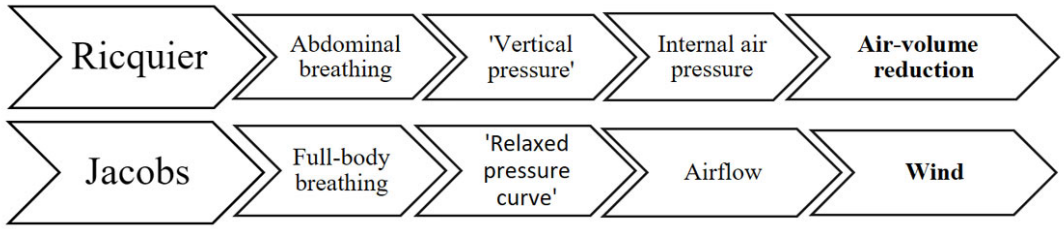


Figure 1. Comparative respiratory approaches of Ricquier and Jacobs
Source: Based on Cotolí (2025, p. 298).

These differences reflect two substantially distinct conceptions of respiratory control. “The psychology of *wind* is very different than the psychology of pressure. If you go by psychology of pressure, you can have pressure with practically empty lungs” (Frederiksen, 1996, p. 119).

By contrast, the *Individual or Other Approaches* category encompasses predominantly interpretive methodologies, approaches to breathing that emphasise the diaphragm as the primary muscle involved in controlling the air column, and modifications of the vocal tract to facilitate register changes, among other strategies.

In this regard, Bārdiņš and Marnauza state:

> Unfortunately, the uncritical approach to sources has created a situation, when for more than a century methodes of brass playing breathing which teach to breathe contrary to natural breathing processes of a human body have been cultivated, thus creating stress and undesirable muscular tension in the body as well as decreasing the respiratory volume to be used, which in turn negatively influences the quality of sound. (2014, p. 98)

Building on these findings, a field study was conducted during the 2021–2022 and 2022–2023 academic years in the Higher Music Conservatoires of the Valencian Community, administered by the Institute of Artistic Education of the Valencian Community (ISEACV), to investigate whether the divergent respiratory conceptions identified in the literature are reflected in teachers’ and students’ pedagogical conceptions and observable instrumental practices.

The results presented in this study form part of the author's doctoral dissertation. For the purposes of the present publication, the original findings have been synthesized and adapted to provide a focused analysis of the breathing conceptions and practices identified in the study and to contribute to a broader understanding of breathing pedagogy in trombone instruction.

Methodology

To obtain relevant information within this naturalistic context while preserving the conditions under which teaching and instrumental practice normally occurred, a field study involving trombone teachers and students at these institutions was conducted. Two complementary dimensions were distinguished: (I.) the knowledge and conceptions underlying the breathing methodologies implemented by teachers and students; and (II.) the breathing methodology observable in the students' instrumental practice.

A mixed-methods observational study was conducted, integrating qualitative and quantitative procedures to describe and interpret breathing conceptions and selected observable behaviours during instrumental performance.

The research design combined three primary sources of information:

Table 1. Research techniques and specific objectives of the empirical study

	Research tools	Data analysis, collection and experience management	Specific objectives
STUDY 1	Professor interviews Documentary analysis of course guides	MAXQDA	Determine teachers' pedagogical orientations.
STUDY 2	Student questionnaire	QUALTRICS	Identify students' reported conceptions.
STUDY 3	Audiovisual recording of musical excerpts	Audio/video recording MAXQDA	Direct observation and audiovisual analysis of students' instrumental practice.

Source: Based on Cotolí (2025, p. 147)

This design enabled a methodological triangulation strategy based on the comparison of information reported by teachers, information reported by students, and selected observable behaviours during instrumental practice. The analysis was conducted from a pedagogical perspective, with the researcher's dual role as teacher and researcher providing specialized experiential knowledge that contributed to a more contextualized

and in-depth understanding of the phenomenon under investigation (Kemp, 2012). The results of this triangulation informed the classification of the breathing methodologies prevailing within this authentic educational context.

To ensure coherence and maintain a clearly defined structure throughout the research project, we adopted the general analytical model also used in the preceding theoretical framework:

Table *2*. General analytical model

Parameter I Pedagogical foundations	Pedagogical foundations	
	Pedagogical resources	
	Physiological and anatomical knowledge of respiration	
	Methodology: procedural vs interpretative	
Parameter II Methodological aspects of breathing	Body posture and embouchure	Observable Muscular Tension Musculoskeletal History
	Inspiration	Type of breathing
	Exhalation	Formation, Control and Support of the air column Air management Register changes

Source: Based on 'Analysis Model by Parameters' (Cotolí, 2025, p. 154)

The following section presents the research tools and techniques employed in each of the proposed studies.

Study 1. Teachers' Pedagogical Conceptions

To identify the breathing orientations employed by the teaching staff, two complementary sources of information were used: semi-structured interviews and documentary analysis of trombone teaching guides.

The interviews consisted of open-ended questions designed to identify teachers' conceptions regarding inhalation, exhalation, respiratory support, control of the air column, register changes, and the use of pedagogical resources.

The teaching guides were analysed to identify explicit references to breathing and to the procedures used for its instruction.

The qualitative data were processed and coded using MAXQDA. Initial categories were established on the basis of the conceptual model developed in the theoretical framework and were subsequently complemented by emergent codes derived inductively from the data.

For ethical reasons, the responses of the teacher-researcher were excluded from the analysis, as the researcher was also a member of the study population.

Study 2. Students' Breathing Conceptions

To identify the breathing methodologies that predominated in students' knowledge and conceptions, a questionnaire was administered comprising open-ended, dichotomous, multiple-response, and multiple-choice questions. The questionnaire explored students' conceptions regarding breathing type, air control, respiratory support, register changes, the use of pedagogical resources, and the presence of previous musculoskeletal discomfort or disorders.

The data were processed and analysed using MAXQDA. Categorization was conducted with reference to the general analytical model described above.

Study 3. Observation of Instrumental Practice

The third study focused on the analysis of selected observable behaviours during students' instrumental practice. Individual audio and video recordings were made while students performed previously established exercises and musical passages. All recordings were made using the same digital camera and the same audio input gain, at an approximate distance of two meters, with the camera positioned to capture the student's left side, thereby enabling detailed observation of body posture and embouchure.

The use of audiovisual observation procedures is particularly relevant in the field of arts education, where certain technical and interpretive processes are difficult to access through other research methods (Moncayo *et al.*, 2023).

The recordings were analysed using a predefined categorical framework. The following table presents a simplified version of the categorization and coding system employed:

Table 3. Simplified coding: Study 3

CATEGORIES	CODE	SUBCODE
BODY POSTURE	Balanced / Unbalanced	Back (straight/curved), raised shoulders, tilted head…
	Observable Muscular Tension	Embouchure; Neck; Upper chest region
INSPIRATION	Type of breathing	Abdominal; Diaphragmatic; Thoracic; Full; Shallow
EXHALATION	Air management	Effective / Ineffective
	Breathing methodology	Upstream air / Downstream air
	Observed tensions (F5; Db5; Bb4)	Upper chest and embouchure
	Register changes	Observational Coding System Physiological Interpretation of the Results

Source: Based on Cotolí (2025, p. 214)

Given the complex and multifactorial nature of instrumental sound production, the observational categories were interpreted as descriptive indicators rather than as direct equivalents of physiological variables. The audiovisual data were processed and analysed using MAXQDA.

Participants

The following table presents the participation of the study population in each of the three studies:

Table 4. Study Population and Sample Sizes

	Study 1 Professors' theory	**Study 2** Students' theory	**Study 3** Students' instrumental practice
Study population	8 professors	59 students	59 students
Sample population	7 professors: 87.5%	57 students: 96.6%	37 students: 63%

Source: Based on Cotolí (2025, p. 249)

Seven of the eight trombone teachers participated in the study, corresponding to 87.5% of the total population. The teacher who participated in the study as a researcher was excluded from the analysis to avoid the inclusion of the researcher's own data.

Participation in the student questionnaire was very high, with 57 of the 59 students responding, representing 96.6% of the population. Participation in the third study was lower, involving 63% of the students.

Parameter I. Pedagogical Foundations

This parameter was examined in Studies 1 and 2, which analysed the theoretical conceptions of breathing held by teachers and students.

Pedagogical Foundations

Most teachers did not use specialized literature on breathing pedagogy, relying instead on knowledge acquired through professional training and personal experience. A minority referred to prominent pedagogues, including Jacobs, Ricquier, and Wick. Other influences included yoga, relaxation techniques, and sports, mainly used to promote physical and mental balance.

Among students, the main pedagogical sources were sports activities and breathing exercises, while social media, breathing devices, airflow-monitoring resources, specialized literature, Eastern disciplines, and postural techniques were reported less frequently. Overall, both groups reported limited use of specialized literature and online resources, with instrumental training and personal experience representing the most direct and common sources of knowledge.

Anatomical and Physiological Knowledge

In the interviews, four teachers demonstrated accurate anatomical and physiological knowledge concerning breathing. However, inaccurate or unclear conceptions were identified in three teachers, particularly regarding lung capacity and the function and proprioception of the diaphragm.

Similarly, the analysis of the student questionnaire revealed a lack of knowledge and some confusion regarding the location and function of the principal muscles involved in breathing, particularly the diaphragm. This lack of clarity, observed among some teachers and a substantial proportion of students, may be related to misconceptions and myths concerning the natural processes of human breathing that are reflected in specialized literature on brass instruments and voice pedagogy (Bārdiņš & Marnauza, 2014; Michael, 2010).

Procedural and Interpretive Methodologies

Three methodological orientations were distinguished:

- *Procedural:* predominance of conceptual explanation, bodily awareness, and the deliberate application of physical procedures.
- *Interpretive:* predominance of musical intention, singing, imitation, and attention to the resulting sound.
- *Combined:* integration of procedural and interpretive elements.

The results for this subcategory are presented in the following table:

Table 5. Procedural versus Interpretive methodology

	Interpretive	**Procedural**	**Combined**
Students	32%	36%	32%
Professors	-	43%	57%

Source: Based on Cotolí (2025, p. 253)

The data indicate that the methodology reported by students was distributed relatively evenly across the three proposed categories, with the procedural orientation receiving the highest proportion, at 36%. Among teachers, combined methodology was predominant, accounting for 57% of responses, while 43% reported a predominantly procedural methodology.

These findings suggest that breathing instruction in the educational context examined does not correspond to a single methodological model, but rather involves a combination of bodily, respiratory, and musical procedures.

Parameter II. Methodological Aspects of Breathing

Posture and Embouchure

The results showed that the teaching staff considered maintaining appropriate posture to be relevant, although the degree of explicit attention given to this aspect varied among teachers.

To analyse body position during instrumental practice, two dichotomous categories were established: balanced and unbalanced. A balanced body position was defined as one in which the body was aligned with its centre of gravity, whereas an unbalanced position was defined as one in which the body deviated from the line of gravity.

The results of the analysis of instrumental practice in relation to this aspect are presented in the following table:

Table 6. Body posture

Balanced	Unbalanced
38%	62%

Source: Based on Cotolí (2025, p. 219)

During instrumental practice, 62% of the students exhibited some degree of postural imbalance according to the established observation criteria, whereas 38% maintained a position classified as balanced.

These findings should be interpreted descriptively. Nevertheless, inappropriate body posture may interfere with respiratory mechanics during wind-instrument performance by reducing the efficiency of whole-body coordination and potentially contributing to unnecessary muscular tension (Elgström, 2017).

Regarding embouchure, the data indicated that teachers emphasised its importance while also acknowledging the pedagogical difficulties that an inappropriate embouchure could entail. Indeed, the interviews revealed concern and uncertainty regarding this aspect.

Observable Muscular Tension During Instrumental Practice

From a pedagogical perspective, observable muscular tension was considered a relevant aspect because it may affect bodily coordination and respiratory function. In the present study, it was defined as visible contraction, rigidity, or an apparent increase in muscular effort, particularly in the upper thoracic region, neck, and embouchure. The researcher-teacher conducted the observations using predefined criteria, applying the same procedure systematically across performances of B♭4, D5, and F5, according to the International Pitch Notation system.

The following figure and table present the comparative data on observable muscular tension and the categories used for analysis.

Table 7. Observable Muscular Tension in B♭4, D5 and F5

	No observable tension	Low tension	Moderate tension	Considerable tension	High tension	Not applicable
B♭4	13.5%	35%	38%	13.5%	-	-
D5	-	16.2%	19%	35%	13.5%	16.2%
F5	-	-	8%	8%	19%	65%

Source: Based on Cotolí (2025, p. 222)

At B♭4, 13.5% of students showed no observable tension, 35% showed low tension, and 38% moderate tension.

At D5, no students showed no observable tension; 16.2% did not reach the target pitch or provide usable data. The most frequent categories were moderate tension (19%) and considerable tension (35%).

At F5, 65% did not provide usable data because they were unable to reach or perform the target pitch. Among those who did, 8% showed moderate tension, 8% considerable tension, and 19% high tension.

Overall, observable muscular tension tended to increase with pitch height, particularly in the upper thoracic region, neck, and embouchure. Given the observational nature of the assessment, this pattern should be interpreted descriptively rather than as evidence of underlying physiological changes.

Musculoskeletal History

The questionnaire also investigated previous musculoskeletal problems experienced by the students. Nine respondents (16%) self-reported having experienced some form of musculoskeletal problem. The areas most frequently affected were the middle and upper back, followed by the neck, embouchure, and left arm. Similarly, a study conducted among Catalan musicians found that the anatomical regions most affected by health problems associated with musical activity were the upper extremities and the cervical spine (Rosset i Llobet *et al.*, 2000).

Inhalation

The breathing categories were defined according to participants' pedagogical conceptions and observable patterns of bodily expansion. Terms such as 'Abdominal', 'Thoracic', and 'Full A', 'Full B', and 'Full C' therefore represent pedagogical and observational categories rather than direct measures of lung-air distribution.

The figure below presents each category according to the perceived or directed location of expansion, together with the results obtained through triangulation across the three studies.

Table 8. Type of breathing

	Professors' theory	Students' theory	Students' instrumental practice
Abdominal	14%	-	-
Diaphragmatic	43%	27.5%	-
Thoracic (middle and upper parts lungs)	-	-	35%
Full A (Full lung capacity)	-	22%	-
Full B (Less upper lung region)	-	17%	62%
Full C (Diaphragmatic and abdominal)		27.5%	
Natural-Deep-Relaxed	43%	-	-
Shallow (Without observable expansion)	-	-	3%
Others	-	6%	-

Source: Based on Cotolí (2025, p. 258)

Abdominal breathing was reported by one teacher (14%), while three teachers (43%) reported using a diaphragmatic approach. The remaining three (43%) described their approach as *natural, deep, and relaxed*, without specifying a particular anatomical region.

Among students, the most frequently reported approaches were 'Full C' (27.5%) and diaphragmatic breathing (27.5%), followed by 'Full A' (22%) and 'Full B' (17%). No student selected 'Thoracic' breathing.

Observational coding was based on the predominant region of visible bodily expansion during inhalation. 'Full C' accounted for 62% of observed patterns, while 35% showed predominantly upper- and middle-thoracic expansion. Thus, although no student reported using thoracic breathing, it was observed in 35% of cases, revealing a discrepancy between reported conceptions and observed breathing behaviour.

Overall, triangulation indicated a divergence between self-reported breathing conceptions and observable breathing patterns during instrumental practice.

Exhalation

Theoretical concepts regarding the formation and control of the air column

Continuity of the airflow was the most frequently reported pedagogical conception among the teachers. Six of the seven participants explicitly referred to the need to maintain continuous airflow, using expressions such as ‘do not interrupt the air’, ‘continuously feed the vibration’, or ‘maintain the direction of the phrase’. The strategies used to promote this continuity included flexibility exercises, glissandi, singing, imitation of the human voice, and adapting breathing to the musical passage.

In the questionnaire, students showed a high degree of agreement with the concept of continuous airflow, as well as with the use of broad, relaxed breathing. They also showed considerable agreement with adapting breathing to the musical passage and with concepts associated with singing and ‘air in motion’.

Pedagogical conceptions of Respiratory Support

The analysis identified two principal bodily regions in which teachers located the concept of support: the abdominal region and the embouchure. Three of the seven teachers explicitly referred to the use of abdominal support. Similarly, three teachers emphasised the need to sustain, stabilize, or control the embouchure, directing attention toward this region as a point of support.

Among the students, the predominant conception of support was associated with reducing physical effort and using the available air efficiently. Although less strongly endorsed, the responses also included the idea of consciously controlling the diaphragm and generating pressure through the abdominal musculature.

Air Management During Performance

To examine respiratory management during instrumental performance, a well-known melodic passage from Marco Bordogni was used as a standardized performance task.



Figure 2. Proposed melodic excerpt
Source: Based on Rochut (1995, p. 2)

Air management was classified into two broad categories:

- *Adequate air management:* breathing adapted to the phrasing, character, dynamics, and specific characteristics of the passage, without unnecessary respiratory interruptions.
- *Suboptimal air management:* the use of additional breaths not apparently justified by the phrasing, or a perceptible decrease in sound quality toward the end of one or more phrases.

The results of the air-management analysis are presented in the following table.

Table 9. Air management (Study 3)

AIR MANAGEMENT	**Adequate air management**	**Suboptimal air management**		TOTAL
		Loss of quality	More breaths than necessary	
Instrumental performance	24%	22%	54%	100%
		76%		

Source: Based on Cotolí (2025, p. 230)

Overall, 76% of students showed inadequate air management: 54% took more breaths than required for the phrasing, while 22% showed a perceptible decline in sound quality toward the end of at least one phrase. The remaining 24% demonstrated adequate air management. These findings indicate a discrepancy between reported breathing conceptions and observed respiratory behaviour.

Register Changes

Continuity of airflow was the principal strategy reported by teachers for facilitating register changes. Other strategies included singing, reducing physical effort, and modifying vocal-tract configuration. Several teachers and students also reported vowel-like configurations, using A for the low register, E for the middle register, and I for the high register. This may represent a pedagogical strategy for modifying vocal-tract configuration during register transitions.

During instrumental practice, observable bodily tension tended to increase with pitch, while auditory analysis revealed a progressive deterioration in perceived sound quality in the upper register among a substantial proportion of participants. This was characterized by a sound perceived as more constricted, forced, and less free.

Physiologically, these observations may be compatible with changes in respiratory coordination and upper-airway configuration. Increased upper-airway constriction could, in principle, increase resistance to expiratory airflow and alter pressure conditions up-

stream of the lips. However, these mechanisms were not directly measured and should therefore be regarded as hypotheses rather than demonstrated causal relationships.

From a pedagogical perspective, certain approaches may potentially promote greater restriction within the airflow pathway and increased upstream pressure, with possible effects on sound production.

The principal pedagogical approaches identified also differed in their methodological foundations. Ricquier sought to increase air pressure through 'vertical pressure', describing the air as moving downward during inhalation and continuing downward during exhalation, thereby compressing the air at the base of the lungs (Ricquier, 1982). In contrast, Jacobs advocated that students approach playing with the concept of 'Song and Wind' rather than 'Song and Air Pressure'.

The relationship between airflow and air pressure has long presented a conceptual difficulty for wind-instrument players. Air pressure uses the same musculature as air as *wind*. However, the musculature is used in different ways. "With *wind* there is always air pressure. With air pressure, there is not always *wind*" (Frederiksen, 1996, p. 119).

Taken together, these conceptions highlight airflow and air pressure as a key point of divergence between the respiratory approaches.

Analysis of the Loss of Sound Quality During Ascent into the Upper Register During Instrumental Practice

Observational Coding System

Based on these considerations, an observational coding system was established to identify two differentiated patterns of behaviour during ascent into the upper register: *Upstream air* and *Downstream air*. These categories were defined exclusively as observational and perceptual-auditory descriptors and were not intended to represent direct measurements of intraoral pressure, subglottal pressure, or airflow, as obtained in experimental studies.

Upstream air: a pattern in which, during ascent into the upper register, a reduction in perceived freedom of the sound was observed, together with auditory characteristics interpreted, within the pedagogical framework of the study, as indicative of increased pressure retention.

Downstream air: a pattern in which the sound retained greater perceived freedom and continuity during the ascent, with no perceptible changes interpreted, within the pedagogical framework of the study, as indicative of pressure retention.

The exercise consisted of an ascending passage from F1 to F5. When a perceptible change in sound quality was identified, the pitch from which the change became apparent was coded as 'Upstream air' starting from the note identified with this categorization. Conversely, when no perceptible deterioration in sound quality was identified, the performance was classified as *Downstream air* up to the highest note reached. The results of this analysis are presented in the following table:

Table 10. Upstream air / Downstream air

Upstream air	Students		*Downstream air*	Students	
From D5	35.14%	94.6%	Up to F5	2.7%	5.4%
From B♭4	48.65%				
From F4	8.11%		Up to D5	2.7%	
From D4	2.7%				

Source: Based on (Cotolí, 2025, p.230)

The results showed a predominance of the *Upstream air* pattern, observed in 94.6% of students, while 5,4% maintained *Downstream air* throughout the exercise. The perceptible change occurred at B♭4 in 48.65% of students and at D5 in 35.14%. Thus, most participants showed a perceptible change during ascent into the upper register, characterized by reduced perceived sound freedom and increased apparent physical effort.

Physiological Interpretation of the Results

The findings suggest that, for most students, ascent into the upper register was accompanied by changes in air-column management, manifested acoustically as progressively more effortful sound production. Within the observational framework, this pattern was interpreted as an indirect indicator potentially compatible with changes in airflow and pressure conditions. However, the procedure did not allow us to determine whether these changes were associated with increased intraoral pressure, altered airflow, vocal-tract configuration, muscular activity, or a combination of these factors.

This interpretation is supported contextually by experimental research with wind-instrument performers. Eckley (2006) reported that increasing technical difficulty was associated with greater lateral tension in the laryngeal region and increased vocal-tract constriction. Similarly, Fréour and Scavone (2010), in a study involving five trombonists, observed that all participants raised the tongue as playing frequency increased and found that different tongue configurations modified the upstream pressure spectrum near the lips. These findings suggest that changes in vocal-tract configuration may influence the acoustic and pressure conditions of the system during instrumental performance.

Taken together, these findings allow us to hypothesize that the *Upstream air* pattern observed in the present study may be associated with increased muscular activity and/or modifications in upper-airway configuration, potentially affecting airflow resistance and pressure conditions upstream of the lips. It should therefore be understood as a perceptual-auditory and observational pattern compatible with this hypothesis, rather than as evidence of increased intraoral pressure or physiological airway obstruction.

The findings also suggest a possible discrepancy between the reported conception of ‘minimum effort’ and the motor behaviour observed during performance. Nevertheless, because the present study did not include direct measurements of intraoral pressure,

airflow, subglottal pressure, or laryngeal muscle activity, these mechanisms cannot be directly established. The interpretation should therefore be regarded as a physiological hypothesis derived from perceptual-auditory and visual indicators rather than as a demonstrated mechanism.

Hypothetical feedback model

On the basis of these findings and the preceding evidence, the following hypothetical feedback model is proposed as a possible framework for explaining the loss of sound quality observed during ascent into the upper register.

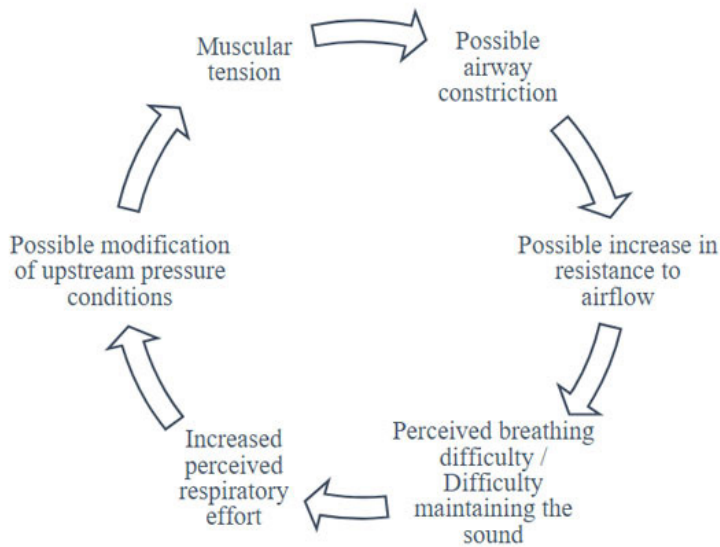


Figure 3. Hypothetical feedback model
Source: Prepared by the author for this article

The proposed model is also consistent with the observations reported by Sataloff *et al*. (1990), citing Eckberg, who describes a potential cycle in which increased airflow effort may lead to throat constriction, greater abdominal effort, and further muscular tension, potentially resulting in restricted range and reduced sound quality. This account provides a useful pedagogical framework for interpreting the present findings, but does not constitute experimental evidence of the physiological mechanisms proposed here.

Classification of Breathing Pedagogical Approaches

To classify the pedagogical orientations identified in the educational context, the three analytical categories established in the theoretical framework were used: Ricquier, Jacobs, and Individual or Other Approaches.

The classification did not seek to establish participants' absolute affiliation with a particular pedagogical school, but rather to estimate the degree of affinity between the empirical data and the defining features of each category. Three principal dimensions were considered, as shown in the following table:

Table 11. Breathing Pedagogical Approaches

	Ricquier	**Jacobs**	**Individual or Other Approaches**
Methodological orientation (0-1)	Procedimental	Both combined	Interpretative
Type of breathing (0-2)	Abdominal	Full breathing	Diaphragmatic breathing or others
Formation and control of air column (0-2)	Support idea Vertical pressure Air pressure Abdominal belt Use of the glottis	No support Song and wind Air Flow Minimal muscular effort. Blow towards the lips	Individual or other approaches Vocal tract Modifications Use of the diaphragm
Total 5	R-(0-5)	J-(0-5)	O-(0-5)

Source: Based on Cotolí (2025, p. 320)

Each dimension was assessed using an ordinal scale according to its weighting: 0–1 for methodological orientation and 0–2 for type of breathing and air-column formation and control. Scores across the three dimensions were summed to obtain an affinity score ranging from 0 to 5, with higher scores indicating greater correspondence with each pedagogical orientation. Mean scores were then calculated across participants, with decimal values representing the relative affinity with each orientation and facilitating comparisons.

Table 12. Assessment of the pedagogical approach of the empirical studies

	Ricquier	**Jacobs**	**Individual or Other Approaches**
Study1: Teachers' Pedagogical Conceptions	R- 1.7	J- 1.9	P- 1.4
Study 2: Students' Pedagogical Conceptions	R- 1.1	J- 2	P- 1.9
Study 3: Observation of Instrumental Practice	R- 1.4	J- 1.6	P- 2
Breathing Pedagogical Approaches CSMCV	**R- 1.4**	**J- 1.8**	**O- 1.8**

Source: Based on Cotolí (2025, p. 270)

The results showed the coexistence and combination of different conceptions of breathing in trombone teaching within the educational context analysed during the 2021–2022 and 2022–2023 academic years.

Discussion

A principal finding was the discrepancy between reported breathing conceptions and certain behaviours observed during instrumental practice. Although teachers and students frequently referred to relaxation, airflow continuity, reduced physical effort, and phrasing-based breathing, observation revealed increased muscular tension and difficulties in air management among a considerable proportion of participants.

Breathing control during ascent into the upper register was particularly relevant. The auditory observations, together with the reviewed literature, suggest that breathing strategies, vocal-tract configuration, and/or embouchure may interact in trombone sound production.

The increase in observable muscular tension and perceived loss of sound quality may be interpreted as phenomenological indicators of increased motor-control demands. In this regard, Sataloff *et al.* describe a compensatory relationship in which:

> […] if the column of air is not sufficiently constant and powerful to drive the instrument or voice, the performer usually attempts to compensate with excessive muscle contraction not only at the oscillator, but also elsewhere in the head or neck. […] Similar changes occur in instrumentalists. Tightening of the lips, increased pressure of the mouthpiece against the mouth, and forceful biting of single-reed instruments are the most prominent changes. However, tongue retraction, tightening of neck muscles, and pharyngeal constriction also occur and appear to affect sound quality and the performer's endurance (1990, p. 96).

However, this framework does not provide direct evidence that the same mechanisms occurred in the participants observed in the present study. The self-reported musculoskeletal complaints among students are also relevant, although no causal relationship can be established with the respiratory or postural patterns observed. This finding is consistent with Rosset i Llobet (2006), who emphasises the relevance of breathing, posture, and relaxation in addressing such disorders. Granell *et al.* (2010) likewise note that the relationship between wind-instrument playing and respiratory function remains controversial and may depend partly on instrumental technique.

The findings allow hypotheses to be formulated regarding possible interactions among respiratory control, muscular activity, upper-airway configuration, airflow resistance, pressure conditions upstream of the lips, and sound quality. These relationships should be considered hypothetical rather than demonstrated causal mechanisms. Accordingly, the present study should be understood primarily as a contextual description of pedagogical conceptions and observable performance patterns, providing an empirical basis for identifying divergences between reported conceptions and practice and for guiding future experimental and longitudinal research.

Limitations

One of the main limitations of the present study concerns the analysis of instrumental practice, which relied on audiovisual observation and auditory assessment rather than direct physiological measurements. Consequently, variables such as intraoral pressure, subglottal pressure, airflow, muscular activity, and upper-airway constriction were not directly measured and cannot be inferred from the observational data.

A further limitation concerns the potential for observer-related bias or variability, as the audiovisual analysis was conducted by the teacher-researcher according to criteria established in advance for systematic observational coding. Although these criteria provided a structured framework for the analysis, the interpretation of certain performance-related indicators necessarily involved researcher judgment.

Future research should therefore incorporate procedures to assess the reliability and consistency of observational coding, such as independent coding by multiple trained observers and the calculation of appropriate inter-rater reliability coefficients. Where feasible, blinded or independently conducted coding procedures could further reduce the potential influence of researcher expectations and strengthen the methodological robustness of the findings.

Conclusions

The present study provides empirical evidence of the coexistence of different conceptions of breathing within higher trombone education and identifies a relevant divergence between reported pedagogical conceptions and certain behaviours observed during instrumental practice.

The proposed analytical classification showed the highest affinity scores for the *Jacobs* and *Individual or Other Approaches* orientations (1.8 each), followed by the *Ricquier* orientation (1.4). These results suggest the coexistence of different pedagogical conceptions within higher trombone education rather than a predominance of a single, clearly defined methodological model. The distribution of scores further indicates that these orientations should not be understood as completely discrete or ‘pure’ pedagogical models, but rather as analytical categories that may overlap within teaching practices.

During instrumental practice, an increase in observable muscular tension was identified in specific bodily regions as pitch increased. In some participants, this was accompanied by perceptible changes in sound quality and difficulties in air management. These findings describe observable performance patterns but do not establish the physiological mechanisms underlying them.

In particular, the hypothetical feedback model proposed (Figure 3) should therefore be understood as a possible framework for explaining the loss of sound quality observed during ascent into the upper register. Such explanations should be regarded as physiological hypotheses requiring experimental verification.

The findings nevertheless provide a basis for a testable hypothesis concerning the potential interaction among respiratory strategies, muscular activity, upper-airway configuration, airflow resistance, pressure conditions upstream of the lips, and sound quality during ascent into the upper register. As emphasised by Sataloff *et al.* “Effective respiratory function is essential for satisfactory performance by vocal, woodwind, and brass instrumentalists” (1990, p. 96).

Future research should integrate observational and experimental methodologies within a mixed-methods framework. Such research could determine whether the perceptual and observational patterns identified in the present study correspond to specific physiological and aerodynamic changes during upper-register playing. It could also provide a stronger empirical basis for evaluating contrasting respiratory pedagogies in trombone instruction and potentially inform research into related pedagogical issues in other wind-instrument disciplines.

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Conflict of Interest

The author declares that they have no conflicts of interest that could have influenced the research, analysis, or interpretation of the results.

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