Effectiveness and Implementation of a One-Day Voice Preventive Program for Primary-School Teachers: A Longitudinal Study Based on Acoustic and Subjective Evaluations

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SUMMARY: A longitudinal study was conducted over 5 months on 22 primary school teachers without existing vocal disorders to assess the effectiveness of a 1-day preventive voice intervention in limiting vocal deterioration over the school year, improving vocal endurance throughout a workday, and promoting the adoption and maintenance of healthy vocal habits.

A combined analysis of the variation of objective acoustic parameters [f_0, Jitter, Shimmer, and harmonic to noise ratio (HNR)] throughout a workday showed that the intervention group (TEST) maintained a typical endurance profile across the school year, while the control group (CTRL) exhibited increased atypical vocal responses. Subjective assessments further supported the preventive impact, with the TEST group reporting reduced vocal discomfort and communication difficulties immediately after the intervention. Self-reported behavior frequency indicated significant progress and long-term retention of key recommendations, including "hydration," "proper anchoring before projecting voice," "giving short instructions," and distance communication strategies. Some of these recommendations also negatively correlated with vocal complaints and workday acoustic variations, suggesting their preventive relevance.

These findings support the effectiveness of this 1-day voice prevention program in limiting vocal deterioration and fostering sustainable behavioral changes. This study provides new insights into selecting the most impactful strategies to further improve the applicability and effectiveness of future preventive programs.

Key Words: Prevention–Occupational disorders–Voice disorders–Vocal health–Teacher–Mixt intervention.

INTRODUCTION

Voice is an essential occupational tool for 30% of the working population.[1] Professional voice users are defined as people who rely on a consistent, special, or appealing voice quality as a primary tool of their trade. If afflicted with dysphonia or aphonia, they are generally discouraged in their jobs and may seek alternative employment.[2] Teachers constitute the largest group of professionals seeking medical advice for voice-related issues.[3] They represent 20%-25% of the treatment-seeking workers at voice clinics for dysphonia.[3,4] Epidemiological studies have shown a higher prevalence of voice disorders among teachers compared with the general population.[5–8] In terms of diagnosis, vocal nodules are among the most frequently encountered pathologies in teachers.[3,9]

Voice disorders affect both physical and psychological health and pose a significant public health concern due to their considerable economic impact, including medical costs and the need for teacher replacements.[1,5] Additionally, these disorders have been shown to interfere with quality of life, psychoemotional state, job satisfaction, performance, and attendance.[5,10,11] Furthermore, teacher dysphonia negatively impacts students' comprehension and learning.[12–17]

Currently, in France, initial training of teachers does not include education on voice care or strategies for preserving vocal health throughout their careers. Some optional prevention programs are available later in their careers, provided by the school education system or certain medical insurances. However, these programs are often brief and reach a limited number of teachers, many of whom seek them out only after already developing voice disorders.

The objective of the present study is to evaluate the effectiveness of such a 1-day preventive program, when provided at the beginning of a teaching career, before any voice disorders have developed. The study aims to assess its impact on reducing the development of vocal fatigue over the course of the year, as well as the application and retention of the protective vocal care strategies.

Existing programs of prevention: content, organization, and participants

Content and approach

Three different approaches are currently used in prevention programs[18]:

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Indirect methods provide basic information about voice anatomy and production, along with simple recommendations for avoiding factors that contribute to, or maintain, voice problems (hydration, vocal warm-up, alcohol consumption, smoking, vocal rest, favorable environments, …).[19–35] These interventions can be extended by keeping a diary of vocal abuses over a certain period to develop and maintain awareness of risk factors.[21,36,37]

Direct methods primarily focus on teaching fundamental vocal techniques, largely inspired by singing and acting techniques, such as *Vocal Function Exercises*,[38] *Resonant Voice Therapy,*[39] and the *Accent Method*.[40] These approaches aim to improve vocal tonicity and endurance, while optimizing vocal efficiency through enhanced breath control, posture, vocal projection, resonance, and articulation.[28,32,41–47] Training supervised with a specialist is sometimes supplemented with daily vocal exercises at home during the intervention period.[21,25,32,43–45,48–50] In a few studies, direct prevention methods resemble medical treatments, such as inhalation of saline solution,[34] or involve the use of external devices, like voice amplification.[33,44] A recent study focused on improving teachers' communication efficiency in noisy conditions through virtual reality training sessions.[51]

Mixed approaches, which combine both direct and indirect methods, are used in most recent studies.[21,22,24,25,27,30,31,36,37,41,47–60]

Organization

The duration and frequency of the interventions vary considerably across studies: from a single session[19,20,24,29,36] to eighteen sessions,[49] spread over a period ranging from one day[19,20,24,29,36] to one-and-a-half years.[53] Most programs are conducted weekly or every 2 weeks, over a 4- to 8-week period.[23,28,42,48,52,57,61] Programs lasting several weeks typically consist of relatively short sessions, ranging from 30 to 90 minutes.[42,45,46,49,51–53,58–61] One-day programs, which primarily focus on indirect prevention, rarely exceed 2 hours.[24] Most programs involve group sessions, with group sizes up to 100 people or more for indirect prevention,[52] while practical workshops rather involve from 4 to 20 participants.[41,46,52,58] Some programs also incorporate individual sessions,[45,47,50,51,55,61] while others were only given through a digital video disk.[20]

Participants

The vocal health of participants also varies across studies: some focus exclusively on nonpathological participants (ie, primary prevention, occurring before the development of any disorder),[21–23,25,26,28,30,36,41,45,51,53,54,56,57,60] while others involve teachers who have already developed voice disorders (ie, secondary prevention, occurring as soon as the very first symptoms appear, or tertiary prevention, occurring on the long-term, at a stage when the symptoms have become entrenched and chronic).[30,32,33,37,42–44,46–50,59,61] Some studies also include both types of participants,[35] without distinction,[24,27,29,34,55,58] or do not specify their vocal condition.[19,20,52,62]

Individual factors such as gender, age, teaching level, and teaching experience of the participants can also influence their vocal health and the applicability of prevention advice. A significant prevalence of voice disorders has been observed in women, compared with men,[63] with an increased risk during the early years of a teaching career,[64] and also later with aging and hormonal changes.[65] However, no prevention program is particularly tailored to a particular gender or age group. Most of the scientific studies have tested their effectiveness on both men and women of varying ages,[22,23,27,48,52,62] but some of them targeted groups of women only,[21,36,41,45,46,59–61] or men only.[58] Regarding teaching level, it has been shown that teachers in primary education, particularly in kindergarten, are at the highest risk of voice disorders,[66–69] due to high vocal load (very high ambient noise levels requiring high vocal intensity in response, and higher voice pitch when speaking to young children) and nonideal phonatory postures (bent in half, sitting on small chairs, …). In secondary education, the risk of developing voice disorders is increased in certain disciplines, such a physical education, music, or chemistry.[70] However, existing programs of vocal prevention are not particularly adapted to the specificities of teaching levels or disciplines. Most of the previous studies on the impact of prevention programs did not specify or distinguish the teaching level of their participants.[20–22,30,31,34,42,45,54,55,57–59,71] Some studies, however, specifically focused on preschool[36] or primary school teachers.[23,25,26,28,43,46,48,60]

Effectiveness of these programs

Criteria and methodology for evaluation

Different criteria were considered in various studies to evaluate the effectiveness of these programs.

First, some studies using diaries or questionnaires assessed participants' degree of satisfaction and compliance with the program, the uptake of the knowledge provided during the intervention, how participants developed awareness of their own voice after the program, and the extent to which they were able to apply the recommendations in their daily lives.[19–21,23–25,28,29,32,33,36,41,43–45,59,61]

Most studies evaluated the impact of the programs on vocal status,[1] expecting one of the following outcomes:

- an improvement in vocal status for participants who followed the program, measured post intervention, compared with pre-intervention time (without

[1] Beyond the traditional notion of "vocal fatigue," we use the term "vocal status"[72] in this article to more broadly refer to the perception of discomfort or pain, production capacities and difficulties, potential alterations in voice quality and laryngeal condition, and endurance to vocal load.

comparison to a control group that received no prevention).[19,20,34,46,47,58–60]
- a healthier vocal status post intervention for participants who followed the tested program, compared with control participants who received no prevention,[22,23,28–30,37,41,43,45,48–55,61] or received another program of prevention.[21,24–26,31–33,44,57]
- a deterioration in vocal status over time (after a vocal loading task, a working day, or over the year) in control participants who received no prevention, whereas no such deterioration or a reduced one was expected in participants who followed the program.[36,42]

As a result of these different evaluation criteria, some studies involved only one group of participants,[19,20,34,45–47,59,60] while others compared two or more groups, with group sizes ranging from 4[42,45] to 336 participants[19] (70, on average). Furthermore, voice assessments were conducted only at a single post-intervention time in a few studies,[62] while in most cases, vocal status was compared between a pre-intervention reference time (directly before the first session,[19,20,22,28,32,33,42,44,58] the preceding day,[55] or week[24,34]), and one or more post-intervention times (immediately after the last session, on the same day,[19,22,23,32,55] or a week later[29,34,46,58]). In studies that compared the effects of vocal loading on participants who received prevention or not, voice recordings or assessments were conducted not only pre intervention and post intervention, but also before and after the loading task or the working day.[26,36,42,57]

Finally, some longitudinal studies tested the maintenance of the program's potential benefits with an additional postintervention assessment, occurring 8 weeks to 24 months after the program.[19,21,27–29,41,49,50,56]

The vocal status itself was also characterized by varying measures or observations, depending on the study. Almost all studies involved subjective evaluations, based either on perceptual assessments of voice quality by a qualified therapist (using standardized scales such as the GRBAS-I,[41,50,52,54,55,59,60] the RBH,[45,53] or the CAPE-V[34]), or on individual self-assessments of the quality, control, and comfort of one's voice as well as the overall physical and mental well-being (using questionnaires specifically designed for the study[25,26,28,29,42,49,50,62] or standardized clinical tools such as the Voice Handicap Index (VHI),[22,23,27,32,33,41,44–46,48,52,53] the Voice-Related Quality of Life (VRQL),[30,31,61] the World Health Organization Quality of Life,[46] the Vocal Symptom Scale (VoiSC),[59] or the Vocal Disadvantage Index (VDI-10)[59]).

In addition to these subjective evaluations, many studies also involved objective characterizations of vocal behavior through acoustic measurements (eg, Voice Range Profile, minimum or mean Intensity, maximum or mean fundamental frequency, jitter, shimmer, harmonic to noise ratio (HNR), long term average spectrum, smoothed cepstral peak prominence (CPP), and alpha measure),[21,22,25,26,30,33,34,36,41,43,45,46,48–59] aerodynamic measurements (eg, oral airflow, maximum phonation time (MPT), maximum expiratory pressure, and phonation threshold pressure),[22,28,34,41,44–49,52–57,59] or electroglottographic exploration of vocal folds' vibration.[36] Endoscopic exploration of the larynx and perilaryngeal areas was rarely used.[19,21,36,41,47,49,50,60]

In connection with these different measures, varying tasks and experimental situations were considered to characterize vocal status. In most studies, participants were recorded in laboratory or clinical conditions and were asked to perform standard voice assessment tasks, such as sustaining vowels and/or reading a short text,[21,34,36,41,45–47,57–60] establishing a Voice Range Profile,[21,45] or completing a Vocal Loading Test.[53–55]

Summary of previous evaluations

Almost all previous studies on secondary or tertiary prevention—targeting participants who already exhibited vocal symptoms or even lesions on the vocal folds—showed a significant positive impact of prevention programs. Participants who received prevention reported a noticeable reduction in vocal complaints and lower scores on the VHI-physical scale, in particular.[33,41,44,48] In most cases, this was accompanied by improvements in voice quality, as perceived by a clinician[41,43,49,50] or characterized acoustically though measures such as jitter, shimmer, or HNR.[30,33,41,43,48,58] Improvements in vocal capacity were also observed, particularly an increase in MPT.[41,59] However, only four studies reported significant improvements in laryngeal condition, as assessed through videolaryngoscopy.[41,46,47,49]

For secondary or tertiary prevention, short programs that focus solely on indirect prevention only (eg, basic knowledge of voice production and vocal hygiene) do not appear to be sufficient to induce significant subjective or objective improvements.[32,33] In contrast, programs incorporating only direct prevention (eg, regular sessions of vocal exercises with a clinician or at home),[32,42–44,46] or a combination of both direct and indirect prevention[37,41,47–50,59,61] have been found to be effective.

In the case of primary prevention—aimed at participants without initial vocal complaints—the goal is not necessarily to improve vocal function and quality but rather to prevent or limit their deterioration and to develop awareness of one's voice and potential risks. Despite this, most studies found that self-reported vocal complaints, perceived voice quality, vocal capacity (MPT, vocal range), and vocal endurance (over a working day or during a vocal loading test) tended to improve post intervention in healthy participants, mirroring the results seen in studies involving dysphonic participants. In contrast, these indicators tended to

decline over time in control participants who received no prevention.[21–23,25,26,28,36,45,53–57] For healthy participants, a short, indirect program appears to be sufficient to produce significant improvements in voice knowledge, awareness, self-perception, and vocal capacity,[21–23,25,26,28,36,57] but not so much on their voice quality[25,26] and the actual frequency of vocal abuses.[28] Direct or mixed programs tend to yield even greater benefits[26] or, at the very least, more global improvements by impacting multiple dimensions simultaneously, some of which may not improve with an indirect program alone.[22,25,26] It is worth noting, however, that contrary to intuition, some few studies reported comparable or even greater improvements in vocal comfort and capacity following indirect programs than with direct or mixed ones.[21,28]

A few studies specifically compared the effectiveness of these programs between healthy participants and participants with vocal symptoms. Notably, Nanjundeswaran et al (2012), found that an indirect program was sufficient to prevent voice deterioration in healthy participants; however, adding vocal training exercises did not provide additional benefits for this group. In contrast, significant improvements in VHI scores were observed in participants with vocal symptoms only when a mixed program was used—not with an indirect program alone.[27] Similarly, Amir et al (2005) found that the vocal improvements induced by a mixed program were more pronounced in dysphonic participants than in healthy ones.[58]

Some studies also examined the impact of program duration. Thus, Ilomäki et al (2005) confirmed, as expected, that teachers who receive long-term vocal education experience less vocal fatigue and fewer symptoms compared with those who complete only short-term education programs.[62] However, Timmermans et al (2011) found that even a brief intervention—consisting of just three hours of indirect prevention and 3 hours of direct prevention—was sufficient to produce a significant improvement in perceived voice quality and objective indicators of voice capacity (eg, vocal range).[54]

Remaining questions and motivations for this new study

As discussed above, many of the discrepancies observed across studies may arise from differences in participants' vocal status, program content (whether it involves direct, indirect, or mixed prevention), the duration and frequency of the interventions, and the organization of the sessions (whether conducted individually, in small, or large groups). However, a major source of variability in the effectiveness of these programs may also stem from the participants' ability to transfer this knowledge and apply the preventive recommendations in real teaching conditions.

Thus, a key question that emerges from these previous studies is whether participants feel better and experience vocal improvement after attending such programs because they have genuinely followed the advice and modified their vocal behavior and daily habits, or simply due to increased knowledge and awareness of their vocal use, or even as a result of self-persuasion.[2]

So far, several studies on direct prevention have shown that participants generally complied well with the proposed therapy or vocal exercises and successfully integrated them into their daily routine.[23,32,33,43–45] However, this does not necessarily indicate how well they were able to transfer the learned vocal techniques (eg, proper postures, breathing patterns, and vocal projection) to their teaching behavior. In some other studies, participants recorded the frequency of their "misuse behaviors" or "vocal abuses"—without much detail about these behaviors—in a daily log.[21,28,36,41] Chan (1994)[36] observed a decrease in such behaviors following an indirect program of prevention, whereas Pasa et al (2007)[28] found no significant reduction after both direct and indirect programs. Conversely, Bovo et al[41] found that most participants in a mixed prevention program were able to frequently implement two categories of recommendations: "good vocal habits" and "strategies to reduce vocal effort in classroom," whereas advice on vocal techniques such as "good respiration," "good resonance," and "reduced muscular tension," was applied only occasionally.

Further research is needed to gain a more detailed understanding of

1. Which type of advice, and more specifically, which recommendations are more likely to be applied and sustained in the long-term.
2. Independently of their applicability, which recommendations ultimately have the most significant preventive impact on vocal health.

In this context, we designed a mixed prevention program aimed at primary school teachers who have not yet developed voice disorders (primary prevention) and tested its effectiveness in a longitudinal study. In addition to assessing its impact on preventing the deterioration of vocal status throughout the school year—using both objective measures and subjective self-assessments—the main goal of our study was to evaluate the degree of application and retention of various types of recommendations provided during the intervention, covering aspects of vocal hygiene, vocal technique, communication, and pedagogical strategies. The second main objective was to explore the relationship between the degree of application of these recommendations and the participants' level of vocal complaints to estimate their respective preventive potential. The ultimate goal was to identify a select set of the most

[2] With the term "self-persuasion," we refer to psychological mechanisms similar to those involved in the "placebo effect," which can produce subjective benefits from a medical treatment or therapy—benefits that are not necessarily confirmed by objective assessments and cannot be explained by the action of any active substance or informative content. Instead, they stem from the patient's strong confidence in the treatment's effectiveness, or from an unconscious desire to justify or valorize the investment (of time, effort, or money) in that treatment.[73]

TABLE 1.
Description of the Participants

	TEST Group	CTRL Group
Age	33 ± 6.5 years[24–40]	30 ± 5.2 years[24–42]
Teaching level	Kindergarten (N = 4) Elementary (N = 6) Specialized class (N = 1)	Kindergarten (N = 3) Elementary (N = 8)
Working hours per week	23.6 ± 4.3 hours	21.8 ± 6.6 hours
Average number of pupils per class	22.7 ± 4.7	24.5 ± 2.8
Number of smokers	1	1

effective recommendations that should be prioritized in future preventive programs to maximize their effectiveness.

MATERIALS AND METHODS

Participants

Twenty-two French primary school teachers participated in the study, coming from different schools of the same region (the Grenoble area). All were women, as female teachers are more represented in the primary school teaching workforce and have a higher prevalence of voice disorders compared with their male colleagues.[1] None of the participants had a self-reported voice disorder or a voice problem identified by the experimenter at the time of the study based on perceptual analysis. They were selected on having less than five years of experience, as previous studies have shown that most voice disorders develop within the first few years of practice.[50,74,75] Additionally, none of them had previously attended any voice prevention or therapy program, singing lessons, or vocal coaching. Among them, seven were kindergarten teachers, fourteen taught in elementary school, and one worked in a specialized class for children with disabilities.

Half of the participants were randomly assigned to a TEST group (N = 11) and took part in a one-day preventive intervention—described in the next section, while the other half (CTRL group, N = 11) received no information or recommendations. Table 1 summarizes the information gathered from inclusion questionnaires about the participants in both groups.

Preventive voice program

The eleven participants in the TEST group took part in a 1-day preventive voice intervention conducted in September, after the start of the school year, by a phoniatrician specializing in voice disorders among teachers. The program consisted of two four-hour group sessions, separated by a lunch break, and combined both direct[3] and indirect[3] prevention methods. The training day began with a relaxation session focused on body tensions awareness and breathing patterns, providing recommendations on how to release tension throughout the workday (eg, stretching, yawning, etc) (direct prevention). This was followed by theoretical instruction on the anatomy and physiology of the phonatory organs, the principles of voice production, and general advice on vocal hygiene, emphasizing the importance of hydration and incorporating moments of vocal rest throughout the day (indirect prevention). The morning session concluded with a practical workshop on posture and breathing in relation to phonation, covering topics such as vertical alignment, chest expansion, abdominal and diaphragmatic breathing techniques, and body "anchoring"[76] (direct prevention). After the lunch break, the afternoon session began with a second practical workshop on speech articulation, aimed at increasing awareness of facial tension, improving articulation flexibility, and enhancing the production of loud or projected voice, with a focus on the notion of "vocal resonance"[39] (direct prevention). Next, participants engaged in a workshop on communicative and pedagogical strategies. Through role-playing exercises, they explored alternative solutions to reduce vocal strain in challenging situations, such as noisy, agitated, or conflictual environments, or when addressing children from a distance. Particular emphasis was placed on the importance of eye contact and proximity when speaking to a child, the interest of using of nonvocal tools to gain attention or call a child from afar, organization relaxation sessions for the children, promoting active pedagogy, and delegating tasks to pupils (eg, having one child repeat instructions, or sending a child to fetch another instead of shouting from afar) (direct and indirect prevention). A final practical workshop focused on managing musical and singing activities in the classroom, covering aspects such as selecting a suitable vocal pitch and using external supports (direct and indirect prevention). At the end of the day, a collective review of the key concepts was conducted. Each participant identified and shared seven key takeaways from the training that they considered most important. A document summarizing the main recommendations of the program was finally provided to each participant before they left (see Appendix A). In the following, behavioral changes expected to have positive effects on vocal health will be referred to as "protective," whereas behaviors to be avoided due to their expected negative effects will be referred to as "risky."

[3] Based on Van Stan's taxonomy or direct and indirect prevention.[18]

Collected data

The 22 participants, from both the TEST and CTRL groups, were then followed over a five-month period to evaluate, using both objective and subjective descriptors, how their level of vocal complaints varied over the first half of the school year. Three assessment sessions were organized: in October (T0)—which took place just after the preventive intervention for the TEST group; at the end of December, before the Christmas school break (T1); and at the end of February, before the winter school break (T2). Additionally, the study aimed to determine how the frequency of various behaviors—protective or risky according to the prevention program—varied over time in the group of participants who received prevention (TEST group) and the extent to which participants' levels of vocal complaints could be related to the frequency of these behaviors.

Self-reported vocal complaints (subjective assessments)

At these three points in the year, participants from both groups completed a nine-item questionnaire (see Appendix B). Since no short validated tool exists in French to specifically assess the behaviors and complaints targeted in our preventive program, we designed a questionnaire to evaluate participants' levels of vocal complaints across different dimensions:

1. Sensation of fatigue, pain, and discomfort.
2. Experience of decreased vocal capacity and control (eg, running out of breath when speaking; having difficulty increasing volume or modulating one's voice; feeling a loss of control).
3. Experience of communication difficulties (eg, not being understood; being perceived as speaking too softly or too loudly) in various situations.

Six of these items (Q2, Q3, Q4, Q5, Q6, and Q8) consisted of single assessments on visual analog scales with 12 graduations, ranging from 0 (never) to 11 (always). Two items (Q7 and Q9) consisted of multiple assessments of the same difficulty, but in different situations, again using visual analog scales with 12 graduations. However, we considered only one value for the analysis of these items, corresponding to the average score across the different situations. Finally, one item (Q1) was a five-choice question regarding the different body parts where tension or pain was felt. The data from this item were analyzed by counting the number of body parts selected, then rescaling that value to a range between 0 and 11 for consistency and comparison with the other items. The details of these nine items are provided in Appendix B, while they are summarized in Table 2.

Vocal endurance to a workday load (objective assessments through acoustic variations)

At these same three points in the year, each participant was recorded at her school. Twice a day—before and after their teaching day—they produced in a quiet environment five repetitions of the vowel /a/ at a comfortable pitch and intensity, sustained for as long as possible after taking a deep breath. The audio signal was recorded using a portable digital stereo recorder (ZOOM H1, Tokyo, Japan) and a headset microphone positioned approximately 5 cm from the lips (Shure WH20, Niles, IL, USA), on 16 bits and at a sampling frequency of 44.1 kHz.

Four different measures were then extracted from these sustained vowels, using the Praat freeware[77]: the average fundamental frequency (f_0), jitter, shimmer, and harmonic-to-noise ratio (HNR). For each participant and each time point (T0, T1, and T2), we assessed the absolute variation in these parameters before and after the teaching day as objective descriptors of the response to the vocal demand of a workday.

In a previous study,[78] we observed that the variation in these parameters throughout a workday is highly influenced by inter-speaker variability. Three distinct profiles of variation were distinguished:

- Endurance Profile 1, interpreted as an adequate response to vocal demand, and observed in 56% of cases, is characterized primarily by a significant increase in f_0 during the day.
- Endurance Profile 2, interpreted as a hyperfunctional response to vocal demand, and observed in 9% of cases, is mainly characterized by a significant increase in HNR, and a significant decrease in Jitter and Shimmer throughout the day.
- Endurance Profile 3, interpreted as a possible inflammatory response or early sign of lesions on the vocal folds, and observed in 35% of cases, corresponds to an opposite pattern of variation: a significant decrease in f_0 and HNR, and a significant increase in Jitter and Shimmer during the day.

Therefore, in addition to analyzing the average absolute variation of these parameters throughout a workday, we also examined how the proportion of participants exhibiting Endurance Profiles 1, 2, or 3 varied between the two groups (TEST vs CTRL) and over time (T0, T1, and T2).

Self-reported frequency of protective and risky behaviors (subjective assessments)

The participants in the TEST group, who benefited from the preventive intervention, also completed an additional 19-item questionnaire at the three points during the year to assess their degree of application of various recommendations provided during the preventive intervention. The assessment of behavior frequency was made using visual analog scales with 12 graduations, ranging from 0 (never) to 11 (always). These items corresponded to behaviors that were both protective and risky, pertaining to four areas of prevention: 1—vocal hygiene, 2—posture, 3—communicative strategies, and 4—pedagogical strategies. The

TABLE 2.
Summary of the Different Objective and Subjective Measures Collected in the Test and Control Groups

Acoustic measures	Self-reported vocal complaints (from 0 to 11)		Self-reported behavior frequency (from 0 to 11)	
$\lvert\Delta f_0\rvert$	Fatigue, pain, and discomfort	Q1. Tension and pain	Vocal hygiene	*Protective:*
|ΔJitter|				Q10. Vocal rest
|ΔShimmer|				Q11. Hydration
|ΔHNR|	Vocal capacity and control	Q2. Short of breath	Posture	*Protective:*
(On sustained vowels, from beginning to end of the teaching day)		Q3. Perceived strain		Q12. Proper anchoring before projecting voice
		Q4. Loss of control		Q13.3. Crouch down to the child
		Q5. Feeling of disability		*Risky:*
		Q6. Modulation difficulty		Q13.2. Bend down to the child
	Communication	Q7. Not understood	Communication	*Protective:*
		Q8. Speaking too loudly		Q13.1. Turn to the child
		Q9. Communication difficulty		Q14.2. Wait to get silence
				Q14.3. Nonvocal tools to get silence
				Q15.2. Nonvocal tool to call a child from afar
				Q15.3. Move to the child
				Q15.4. Send another peer to get to him/her
				Risky:
				Q13.4. Speak from the desk
				Q14.1. Raise voice to get silence
				Q15.1. Shout to call a child from afar
			Pedagogy	*Protective:*
				Q16.2. Ask a child to repeat instructions
				Q16.3. Short instructions
				Q17. Active pedagogy
				Q18. Children relaxation time
				Risky:
				Q16.1. Repeat instructions

details of these 19 items are provided in Appendix C, while they are summarized in Table 2.

Statistical analysis

Distinct statistical analyses were conducted, using R software.[79]

First, we tested how the level of self-reported vocal complaints—as assessed by the nine items of the first questionnaire—varied throughout the year and across groups, potentially following different patterns for the two groups. A group analysis was conducted for each item, based on a mixed model of the data (using the R package lme4), with TIME (three levels: T0, T1, and T2) and GROUP (two levels: TEST, CTRL) as fixed effects, along with their interaction, and a random effect on participants ($N = 22$). The statistical interaction TIME*GROUP was tested with a likelihood ratio test,[4] while specific contrasts examined more specifically group differences at T0, as well as parameter variations from T0 to T1 and from T0 to T2 within each group (TEST, CTRL), using the R package multcomp.

The same approach was used to examine how the absolute variation in the four acoustic parameters throughout a teaching day ($|\Delta f_0|$, |ΔJitter|, |ΔShimmer|, |ΔHNR|)—considered objective assessments of vocal endurance to a workday load, varied across groups over the course of the year.

Additionally, we examined how the proportion of participants who exhibited a typical response to vocal load during a working day (Endurance Profile 1) varied across groups (TEST vs CTRL) and over time (T0, T1, and T2). A binomial regression was conducted, considering for each participant and time point a binary variable ("Showing or not a typical endurance profile"), using a mixed model of the data with TIME (three levels: T0, T1, and T2) and GROUP (two levels: TEST, CTRL) as fixed effects, along with their interaction, and a random effect on participants ($N = 22$).

Next, we tested how the participants in the TEST group were able to apply and maintain over time the recommendations provided during the preventive intervention. A group analysis was conducted on the frequency scores of the 19 behaviors assessed in the second questionnaire—completed only by the TEST group—using a mixed model of the data, with TIME (three levels: T0, T1, and T2) as a fixed effect and a random effect on participants ($N = 11$). Specific contrasts examined more specifically the significance of each behavior's frequency at T0—compared with an average frequency score of 5.5—as well as variations in behavior frequency from T0 to T1 and from T0 to T2.

Finally, we aimed to determine the extent to which variations in vocal status may be related to the frequency of adopting various behaviors.

In an initial approach, we conducted a repeated-measures correlation analysis (using the R package rmcorr, with repeated measures on the participants), examining pairwise "within-subject" correlation between variations over the year in the frequency of the 19 behaviors (from the second questionnaire), and corresponding variations in vocal status, assessed both subjectively via self-reported vocal complaints (based on the nine ratings from the first questionnaire), and objectively via the daily absolute variation of four acoustic parameters, reflecting the endurance to a workday load. However, the results of this analysis are not easy to interpret: indeed, primary prevention (ie, for healthy individuals) mainly aims to limit the deterioration of vocal status rather than to improve it. Thus, a behavior can be considered preventive if it at least helps maintain a stable level of vocal complaints or slows their progression compared with people who do not adopt this behavior. Consequently, a nonsignificant or even positive within-subject correlation does not allow conclusions about its potential preventive impact. Only significant negative correlations clearly support a behavior's positive impact on vocal health.

Therefore, as a complementary approach, we conducted a second repeated-measures correlation analysis, this time with repeated measures across the three time points in the year (T0, T1, and T2), to examine the "between-subject" correlation between behavior frequency and vocal complaints level. This new analysis aimed to determine whether individuals with lower levels of vocal complaints, regardless of time, were also those who frequently adopted protective behaviors and rarely engaged in risky ones. Its results are more easily interpretable than the first analysis: a significant negative between-subject correlation between the frequency of a protective behavior and the deterioration in vocal status supports the behavior's preventive impact. Conversely, the absence of such a correlation—or the presence of a significant positive correlation—rules out the possibility of a preventive impact.

All results of these statistical analyses were reported using conventional notation: * for $p < 0.05$, ** for $p < 0.01$, *** for $p < 0.001$, and NS (not significant) for $p > 0.05$, with Bonferroni adjustments for multiple comparisons.

RESULTS

Impact of the preventive intervention on changes in vocal status over time

Subjective assessments: self-reported vocal complaints

Let us begin by examining how vocal complaints, as subjectively perceived and self-assessed by participants in the first questionnaire, varied over time and across groups. As

[4] Likelihood Ratio Tests (LRT) are used to compare two "nested" models that differ in the inclusion/exclusion of a factor, or an interaction effect between two factors (the degrees of freedom for this test, *df*, correspond to the difference in the number of parameters between the two models). This type of test assesses the significance of the likelihood ratio (*LRatio*) between the two models, indicating the extent to which the inclusion of the interaction term contributes to explaining variations of the dependent variable.

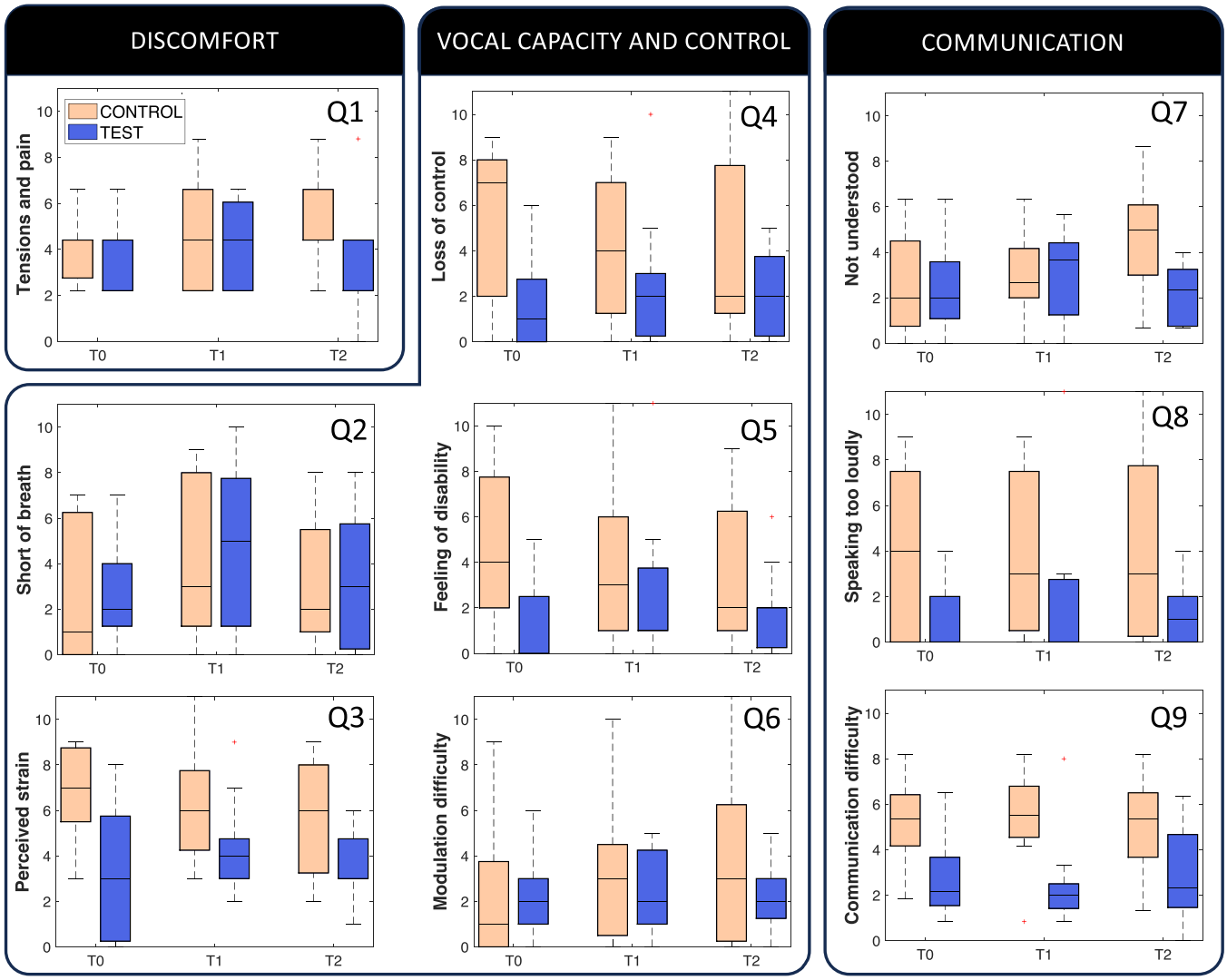

FIGURE 1. Variation in self-reported vocal complaints throughout the year (T0: October; T1: December; T2: February) for the two groups of participants, one who followed a preventive intervention (TEST) and the other one who did not (CTRL).

expected, the score for three items (Q1—tensions and pain; Q6—modulation difficulty; Q7—not understood) tended to increase over the course of the year for the CTRL group, whereas they remained stable or decreased for the TEST group (see Figure 1 and Table 3). This trend was statistically significant only for Q7 (significant interaction Group*Time). The ratings for the other questionnaire items either varied similarly in both groups (Q2—short of breath; Q8—speaking too loudly; Q9—communication difficulty), or followed a trend opposite to our expectations: tending to increase over the course of the year for the TEST group, whereas they remained stable or decreased for the CTRL group (Q3—perceived strain; Q4—loss of control; Q5—feeling of disability). However, all six items that did not follow the expected trend already showed, as early as T0, lower ratings in the TEST group, compared with the CTRL group. This difference was significant for Q3, Q4, Q5, Q8, and Q9 and persisted throughout the year (at T1 and T2).

Objective assessments: vocal endurance to a workday load

As shown in a previous study,[78] voice parameters such as f_0, Jitter, Shimmer, and HNR vary in a highly individual-dependent manner throughout a workday, reflecting the development of different types of vocal fatigue. Therefore, in a first approach, we considered the absolute variation of these parameters throughout a workday.

As expected, the TEST group showed absolute variations in f_0, Jitter, and Shimmer (but not HNR) throughout a workday, which tended to decrease over the course of the year. However, this decrease was not statistically different from the trends observed in the CTRL group (see Figure 2 and Table 4).

In a second approach, we based on the results of a previous study,[78] in which we identified three different individual profiles of variation of these four parameters throughout a workday (from a hierarchical ascending clustering analysis, based on the same vowels produced by

TABLE 3.
Difference in Self-Reported Vocal Complaints at T0 (October) Between the Two Groups of Participants, One Who Followed a Preventive Intervention (TEST) and the Other One Who Did Not (CTRL), and Changes in the Level of Vocal Complaints From T0 to T1 (December), and From T1 to T2 (February) for Both Groups

	Group diff at T0 (TEST-CTRL)	Interaction GROUP*TIME	Changes in the level vocal complaints (from T0)	
			T1	T2
DICOMFORT				
Q1 – tension and pain	-0.6 ± 0.8, p=0.46	df=2, LRatio=4.18, p=0.12	CTRL: +0.4 ± 0.5, p=0.43 TEST: +0.6 ± 0.5, p=0.24	CTRL: +1.2 ± 0.5, p=0.019 * TEST: 0.0 ± 0.5, p=1
VOCAL CAPACITY AND				
Q2 – short of breath	-1.7 ± 1.2, p=0.15	df=2, LRatio=0.009, p=0.99	CTRL: +1.7 ± 0.8, p=0.029 * TEST: +1.7 ± 0.8, p=0.029 *	CTRL: +0.5 ± 0.8, p=0.56 TEST: +0.4 ± 0.8, p= 0.65
Q3 – perceived strain	-3.4 ± 1.0, p<0.001 ***	df=2, LRatio=2.41, p=0.30	CTRL: -0.3 ± 0.6, p=0.67 TEST: +0.9 ± 0.6, p=0.16	CTRL: -1.0 ± 0.6, p=0.12 TEST: +0.3 ± 0.6, p=0.67
Q4 – loss of control	-4.1 ± 1.2, p<0.001 ***	df=2, LRatio=4.93, p=0.085	CTRL: -1.5 ± 0.8, p= 0.057 TEST: +1.0 ± 0.8, p=0.22	CTRL: -1.3 ± 0.8, p=0.12 TEST: +0.5 ± 0.8, p=0.50
Q5 – feeling of disability	-3.6 ± 1.2, p=0.002 **	**df=2, LRatio=6.20, p=0.045 ***	CTRL: -0.9 ± 0.7, p=0.21 TEST: +1.5 ± 0.7, p=0.033 *	CTRL: -1.4 ± 0.7, p=0.060 TEST: +0.7 ± 0.7, p=0.32
Q6 – modulation difficulty	-0.1 ± 1.1, p=0.94	df=2, LRatio=1.66, p=0.44	CTRL: +1.1± 0.7, p=0.13 TEST: +0.1 ± 0.7, p=0.90	CTRL: +1.3 ± 0.7, p=0.080 TEST: 0.0 ± 0.7, p=1
COMMUNICATION				
Q7 – not understood	-0.2 ± 0.8, p=0.85	**df=2, LRatio=10.36, p=0.006 ** **	CTRL: +0.4 ± 0.5, p=0.49 TEST: +0.4 ± 0.5, p=0.46	CTRL: +1.8 ± 0.5, p<0.001 *** TEST: -0.4 ± 0.5, p=0.49
Q8 – speaking too loudly	-2.6 ± 1.2, p=0.034 *	df=2, LRatio=0.66, p=0.72	CTRL: +0.1 ± 0.7, p=0.89 TEST: +0.6 ± 0.7, p=0.33	CTRL: +0.2 ± 0.7, p=0.78 TEST: 0.0 ± 0.7, p=1
Q9 – comm. difficulty	-2.6 ± 0.8, p<0.001 ***	df=2, LRatio=0.64, p=0.73	CTRL: 0.0 ± 0.4, p=0.92 TEST: -0.2 ± 0.4, p=0.69	CTRL: -0.1 ± 0.4, p=0.89 TEST: +0.2 ± 0.4, p=0.62

Assessments were made using visual analog scales with 11 graduations. Statistically significant results are highlighted in bold, with blue indicating reduced vocal complaints in the TEST group (expected) and pink indicating reduced vocal complaints in the CTRL group (unexpected).

the same 22 participants at the beginning and the end of their workday). The three profiles were interpreted as Typ1—a typical response to vocal load, Typ2—a hyperfunctional behavior, or Typ3—possible inflammation or early signs of vocal lesions (see more details in the "Introduction" or in Remacle et al[78]). Complementary analyses conducted in this present study, from the same data, showed that the proportion of profiles 1, 2, and 3 was comparable in both groups (TEST and CTRL) at the beginning of the year (T0). However, the proportion of profile 1 (typical) remained relatively stable over time in the TEST group who received prevention (one participant moved from profile 1 to 3 over the year), whereas it decreased in the CTRL group (Interaction Group*Time: df = 2, $\chi^2 = 11.52$, $p = 0.003$) (two participants moved from profile 1 to 2, and another from profile 1 to 3 over the year) (see Figure 3). No participant showed a change in profile indicating a restoration of vocal status (ie, a shift from profile 2 or 3 to profile 1) over the course of the year, whether following the preventive program (TEST group) or without any intervention (CTRL group).

Application of preventive recommendations and their impact on vocal status (for the TEST group only)

As mentioned in the Introduction, a question arises as to what extent the subjective benefits of prevention programs reflect a "real" improvement or merely self-persuasion.[2] One possible way to address this question is by examining whether the program, independent of its anticipated effects on vocal status, has led at least to significant changes in the behaviors presented as "protective" or "risky" during the preventive intervention. If so, it would then be useful to examine the extent to which such behavioral changes can predict the subjective benefits ultimately observed.

Variation in the frequency of protective and risky behaviors

Let us begin by examining to what extent the participants in the TEST group were able to modify their behaviors over time, following the preventive intervention.

A significant progress was observed for four protective behaviors (see Figure 4 and Table 5): Q11—hydration,

TABLE 4.
Difference in the Degree of Absolute Variation of Voice Acoustic Parameters Throughout a Workday, Reflecting Vocal Endurance to a Workday Load, at T0 (October) Between the Two Groups of Participants, One Who Followed a Preventive Intervention (TEST) and the Other One Who Did Not (CTRL), and Variation in Vocal Endurance From T0 to T1 (December), and From T1 to T2 (February) for Both Groups

			Variation in Vocal Endurance (From T0)	
	Group diff. at T0 (TEST-CTRL)	Interaction GROUP*TIME	T1	T2
$\lvert\Delta f_0\rvert$	0 ± 0.2 tones, $p = 0.98$	df = 2, LRatio;= 2.26, $p = 0.32$	CTRL: 0 ± 0.2 tones, $p = 0.94$ TEST: 0 ± 0.2 tones, $p = 0.89$	CTRL: +0.1 ± 0.2 tones, $p = 0.60$ TEST: −0.3 ± 0.2 tones, $p = 0.15$
|ΔJitter|	−0.1 ± 0.1%, $p = 0.31$	df = 2, LRatio = 1.19, $p = 0.55$	CTRL: +0.1 ± 0.1%, $p = 0.40$ TEST: −0.1 ± 0.1%, $p = 0.60$	CTRL: −0.1 ± 0.1%, $p = 0.43$ TEST: −0.1 ± 0.1%, p = 0.41
|ΔShimmer|	+0.5 ± 0.8%, $p = 0.56$	df = 2, LRatio = 3.33, $p = 0.19$	CTRL: +1.2 ± 0.7%, $p = 0.06$ TEST: −0.5 ± 0.7%, $p = 0.48$	CTRL: −0.3 ± 0.7%, $p = 0.69$ TEST: −0.7 ± 0.7%, $p = 0.26$
|ΔHNR|	−1.1 ± 1.7 dB, $p = 0.52$	df = 2, LRatio = 2.61, $p = 0.27$	CTRL: +1.5 ± 1.7 dB, $p = 0.38$ TEST: −1.9 ± 1.7 dB, $p = 0.26$	CTRL: +0.1 ± 1.7 dB, $p = 0.97$ TEST: +0.1; ± 1.7 dB, $p = 0.97$

Q12—proper anchoring before projecting one's voice, Q15.3—move to a child at distance, and Q16.3—give short instructions, which were already moderately followed at T0. Although the trend was not statistically significant, two other protective behaviors tended to be more frequently followed after the preventive intervention: Q15.2—use nonvocal tools to call a child at distance, and Q15.4—send another peer at distance, while their negative counterpart tended to be less frequently adopted: Q15.1—shout to call a child at distance. All seven behaviors were initially (ie, at T0) either poorly followed (average scores significantly below the mean value (5.5) for Q11, Q12, and Q15.2), or moderately followed, so that this progress contributed to raising the frequency of these behaviors to moderate or high levels of application.

On the contrary, three protective behaviors tended to decline over time, while one risky behavior tended to increase in frequency: the trend was statistically significant only for Q13.3—crouch down to the child, and not for Q13.1—turn to the child, Q14.2—wait to get silence, and Q13.4—speak from the desk. However, three out these four behaviors were already adopted at T0 either very frequently for the protective behaviors (average scores significantly above the mean value for Q13.1 and Q13.3) or poorly followed for the risky behaviors (average score significantly below the mean value for Q13.4), so that despite this decline, the protective behaviors remained frequently followed at T1 and T2, while the risky behavior continued to be infrequently adopted.

Finally, eight behaviors did not show any significant variation in frequency over time: some being protective behaviors (Q10—moments of vocal rest; Q14.3—nonvocal tools to get silence; Q16.2—ask a child to repeat instructions; Q17—active pedagogy; Q18—kid relaxation time), others being rather risky behaviors (Q13.2—bending down to the child; Q14.1—raise voice to get silence; Q16.1—repeat instructions). Two recommendations of them always remained poorly followed throughout the year (Q18—allow kid relaxation time; Q16.1—avoid bending down), while four others showed a high degree of interindividual variability: being poorly followed by some participants and very frequently by others (Q13.4, Q14.2, Q16.1, and Q17).

Impact on vocal endurance to a workday load and self-reported vocal complaints

Can the frequency of adopting certain behaviors (protective or risky) predict vocal status, either as subjectively perceived or objectively demonstrated through daily variation in voice acoustic parameters?

Based on the between-subject correlation analysis (ie, considering repeated measures at the three time points throughout the year), ten behaviors can be considered as not having a significant preventive effect on vocal status, because their frequency either shows no significant between-subject correlation with the level of self-reported vocal complaints (subjective) or with the vocal endurance

TABLE 5.
Statistical Significance of the Self-Reported Frequency of Behaviors (From 0: Never to 11: Always) at T0 (October) for the Group of Participants Who Followed the Preventive Intervention (TEST), Compared With an Intermediate Frequency Score of 5.5, and Variation in Frequency of These Behaviors From T0 to T1 (December), and From T1 to T2 (February)

	Behavior frequency at T0	Variation in behavior frequency (from T0)	
		T1	T2
VOCAL HYGIENE			
Protective			
Q10 – Vocal rest	6.8 ± 0.9, p=0.043 *	+0.4 ± 0.6, p=0.58	-0.3 ± 0.6, p=0.67
Q11 – Hydration	2.0 ± 1.1, p=0.001 ***	+2.3 ± 0.7, p<0.001 ***	+1.5 ± 0.7, p=0.024 *
POSTURE			
Protective			
Q12 – Proper anchoring when projecting voice	3.1 ± 0.9, p= 0.005 *	+0.1 ± 0.6, p=0.88	+1.8 ± 0.6, p=0.002 **
Q13.3 – Crouch down to talk to a child	7.8 ± 0.7, p=0.002 **	-0.9 ± 0.4, p=0.041 *	-0.6 ± 0.4, p=0.15
Risky			
Q13.2 – Bend down to talk to a child	6.9 ± 0.7, p=0.045 *	-0.7 ± 0.8, p=0.36	-0.3 ± 0.8, p=0.73
COMMUNICATION			
Protective			
Q13.1 – Turn towards the child	7.2 ± 0.7, p=0.021 *	-1.4 ± 0.8, p=0.074	-0.5 ± 0.8, p=0.50
Q14.2 – Wait to get silence	5.6 ± 1.0, p=0.90	-1.3 ± 0.8, p=0.12	-0.7 ± 0.8, p=0.38
Q14.3 – Non-vocal tools to get silence	7.5 ± 0.8, p=0.008 **	+0.7 ± 0.9, p=0.42	+0.3 ± 0.9, p=0.77
Q15.2 – Non-vocal tools to call a child at distance	1.9 ± 1.2, p=0.002 **	+1.6 ± 1.2, p=0.16	+1.2 ± 1.2, p=0.31
Q15.3 – Move to the child at distance	5.7 ± 0.9, p=0.80	-0.1 ± 0.7, p=0.90	+1.4 ± 0.7, p=0.053 *
Q15.4 – Send another peer to call a child	6.3 ± 0.8, p=0.32	+1.2 ± 0.7, p=0.095	+1.1 ± 0.7, p=0.12
Risky			
Q13.4 – Talk to a child from the desk	1.5 ± 0.8, p<.0001 ***	+1.4 ± 0.9, p=0.15	+0.5 ± 0.9, p=0.56
Q14.1 – Raise the voice to get silence	5.5 ± 0.8, p=0.95	+0.2 ± 0.4, p=0.68	± 0.3 ± 0.4, p=0.54
Q15.1 – Shout to call a child at distance	5.3 ± 0.9, p=0.80	-0.5 ± 1.0, p=0.57	-1.0 ± 1.0, p=0.30
PEDAGOGY			
Protective			
Q16.2 – Ask a child to repeat instructions	6.4 ± 0.9, p=0.36	-0.9 ± 0.7, p=0.18	-0.1 ± 0.7, p=0.89
Q16.3 – Give short instructions	4.6 ± 0.9, p=0.36	+0.3 ± 0.8, p=0.73	+1.5 ± 0.8, p=0.048 *
Q17 – Promote active pedagogy	5.7 ± 1.1, p=0.84	+0.4 ± 1.0, p=0.72	+0.7 ± 1.0, p=0.47
Q18 – Relaxation time for children	4.3 ± 0.9, p=0.16	-0.8 ± 1.0, p=0.42	-0.2 ± 1.0, p=0.86
Risky			
Q16.1 – Repeat instructions	4.2 ± 1.0, p=0.19	+0.7 ± 0.7, p=0.29	+0.5 ± 0.7, p=0.42

Statistically significant results are highlighted in bold, with blue indicating expected observations (increased frequency of protective behaviors and decreased frequency of risky ones), and pink indicating unexpected observations (decreased frequency of protective behaviors and increased frequency of risky ones).

to a workday load (objective) (Q11, Q13.2, Q14.1, Q14.2, and Q15.2), or exhibits a significant correlation in the opposite direction of what would be expected[5] (Q13.1, Q14.3, Q15.1, Q15.4, and Q16.1) (see Tables 6 and 7).

On the contrary, both between-subject and within-subject correlation analyses revealed nine other behaviors, protective (Q10, Q12, Q13.3, Q15.3, Q16.2, Q16.3, Q17, and Q18) or risky (Q13.4), that may have a preventive impact (Table 7). A significant between-subject correlation with the expected sign was indeed observed between their frequency and different self-reported complaints or variations of acoustic parameters reflecting vocal endurance to a workday load, further supported in some cases by significant within-subject correlations with the

[5] A negative correlation is expected between the frequency of a protective behavior and the level of vocal complaints, or the degree of variation in acoustic parameters throughout a workday, whereas a positive correlation is expected for risky behaviors.

TABLE 6.
Degree of Between-Subject (BTW) and Within-Subject (WTN) Correlation Between the Self-Reported Frequency of Different Behaviors (From 0: Never to 11: Always) and Vocal Status, Evaluated Both From the Absolute Variation of Acoustic Parameters Throughout a Workday (Vocal Endurance to a Workday Load) and From Self-Reported Vocal Complaints (From 0 to 11)

	Acoustic parameters				Subjective vocal assessments								
					Pain	Vocal capacity and control					Communication		
	f_0	Jit.	Shi.	HNR	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
VOCAL HYGIENE													
Protective													
Q10				BTW: R=-0.34 p=0.057							WTN: R=+0.45 p=0.030	BTW: R=-0.44 p=0.013	
Q11													
POSTURE													
Protective													
Q12										BTW: R=-0.37 p=0.040		BTW: R=-0.37 p=0.040	
Q13.3			WTN: R=+0.44, p=0.033						WTN: R=-0.42 p=0.046				BTW: R=-0.36 p=0.046
Risky													
Q13.2									WTN: R=-0.43 p=0.040				
COMMUNICATION													
Protective													
Q13.1					BTW: R=+0.40 p=0.027								
Q14.2													
Q14.3	WTN: R=+0.42 p=0.046				WTN: R=+0.49 p=0.018						BTW: R=+0.52 p=0.003		
Q15.2													
Q15.3			WTN: R=+0.44 p=0.037										BTW: R=-0.47 p=0.008
Q15.4						BTW: R=+0.40, p=0.028							
Risky													
Q13.4						WTN: R=+0.49, p=0.019				BTW: R=+0.45 p=0.010			BTW: R=+0.66 p<0.001
Q14.1													WTN: R=-0.56 p=0.005
Q15.1					BTW: R=-0.52 p=0.003	BTW: R=-0.57 p<0.001	BTW: R=-0.36 p=0.044						
PEDAGOGY													
Protective													
Q16.2	BTW: R=-0.35 p=0.053		WTN: R=+0.47 p=0.022										WTN: R=-0.44 p=0.034
Q16.3		BTW: R=-0.40 p=0.025	BTW: R=-0.42 p=0.017										BTW: R=-0.50 p=0.004
Q17										BTW: R=-0.53 p=0.002	WTN: R=-0.41 p=0.052		
Q18											BTW: R=-0.37 p=0.039 WTN: R=-0.50 p=0.016		
Risky													
Q16.1		BTW: R=-0.40 p=0.024 WTN: R=-0.40 p=0.059		BTW: R=-0.39 p=0.030 WTN: R=-0.60 p=0.003				BTW: R=-0.36 p=0.049					

For clarity, only significant correlations ($P < 0.05$) are reported here, with blue and pink highlighting correlations that respectively support or exclude a preventive impact of increasing or decreasing a behavior's frequency.

TABLE 7.
Results Summary: Classification of 19 Behaviors (Protective or Risky) Based on Their Progress or Decline in Application Following the Preventive Program, as Well as Their Potential Impact on Vocal Status (Based on Correlation Analysis)

	Progress		No Significant Change		Decline	
Significant correlation (expected sign)	Protective: Q12, Q15.3 and Q16.3		Protective: Q10, Q16.2, Q17, and Q18 (low)		Protective: Q13.3	Risky: Q13.4
No significant effect	Protective: Q11, Q15.2			Risky: Q13.2, Q14.1	Protective: Q14.2	
Significant correlation (opposite sign)	Protective: Q15.4	Risky: Q15.1	Protective: Q14.3	Risky: Q16.1	Protective: Q13.1	

expected sign as well (Q13.3, Q13.4, Q16.2, Q17, and Q18) (Table 6).

DISCUSSION

The objective of this study was to test the effectiveness of a preventive intervention addressed to primary school teachers who have not developed voice disorders yet (primary prevention), not only in terms of limiting the deterioration of vocal status throughout the school year (as assessed with objective measures or self-assessments), but also in terms of application and retention of the program recommendations. Behind this question, we aimed at determining whether such a primary preventive intervention can be useful and bring vocal improvements, because it really leads to significant and long-lasting protective behavior changes.

Impact of the preventive intervention on limiting vocal status deterioration throughout the school year

The isolated variation of four objective descriptors of vocal quality (f_0, Jitter, Shimmer, and HNR) over the course of the day and the school year did not reveal any significant differences between the two groups of participants, whether or not they followed the preventive intervention. When considering their combined variation, however, and the three types of variation profiles highlighted in,[78] we observed that the proportion of participants exhibiting an "atypical" variation profile—interpreted as hyperfunctional voices or possible inflammation/early signs of vocal lesions—increased over the course of the school year for the CTRL group, whereas it remained stable for the participants who underwent the preventive intervention (TEST group).

Only one subjective vocal complaint (Q7—not understood) revealed, as expected, a significantly greater deterioration over the course of the year in the CTRL group compared with the TEST group. However, among the other items, two of them also showed this expected tendency, although the trend was not statistically significant. Furthermore, the ratings to the other six items were lower (ie, meaning reduced level of vocal symptoms) in the TEST group as early as T0, immediately after the preventive intervention, and that trend persisted throughout the year.

Combined, all these results therefore suggest that the preventive intervention had a significant effect in the TEST group, helping to reduce the perception of discomfort, voice, and communication difficulties or to limit their progression over time, and having prevented three out of 11 participants from shifting into an atypical endurance profile. They provide further support for the effectiveness of mixed prevention programs, in agreement with previous studies having shown a significant effect of such programs on subjective vocal self-assessments,[22,80,81] voice quality or capacity,[22,25,54,55,80,82] or endurance to a vocal loading test.[54,55,81,83]

Application and retention of the preventive recommendations

Now, to what extent do these positive effects on vocal endurance and self-reported vocal complaints truly result from the program content and the consequent behavioral changes following the program?

The results suggest that the preventive program had a significant impact, not only on the participants' vocal knowledge and awareness like those assessed in previous studies,[56,80,81] but also more concretely on modifying their vocal habits and behaviors. Thus, almost all the protective behaviors of the preventive program were, or became, moderately to frequently followed, while the risky ones were, or became, more moderately or rarely adopted. This latter result is in agreement with Chan's study (1994)[36] reporting a decrease in "misuse behaviors" or "vocal abuses" following an indirect program of prevention, whereas no significant reduction was observed in Pasa et al (2007).[28]

A key point to note is that this behavior change does not appear to be easier for any specific category of advice compared with the others (vocal hygiene, posture, communication, and pedagogy); it was observed across all categories. Consequently, this does not justify focusing the content of future preventive programs on a specific category, or neglecting certain categories that may seem too difficult for participants to implement in their work environment. This observation is partly in agreement with a

previous study of Bovo et al[41] that showed that most participants in a mixed prevention program were able to frequently implement "good vocal habits" and "strategies to reduce vocal effort in classroom," whereas advice on vocal techniques such as "correct respiration," "good resonance," and "reduced muscular tension," was applied only occasionally.

In more details, however, two recommendations remained poorly followed and never reached a moderate level of application (Q18—allow kid relaxation time; Q13.2—avoid bending down), suggesting that they should not be prioritized in the content of future preventive interventions. The lack of adherence to these recommendations may be due to participants not perceiving their benefits or not feeling their impact. Additionally, implementing Q18 may require additional skills and further training, such as selecting appropriate relaxing music, knowing what to say and how to say it during the relaxation session, or managing children who may not comply and disrupt others during relaxation time. Similarly, the application of Q13.2 may be hindered by situational constraints, such as limited classroom space—which allows for bending down but not necessarily crouching instead—or physical constraints such as knee pain or muscular fatigue from repeatedly crouching and standing throughout the day.

Conversely, the most significant progress was observed for seven behaviors, some of which were initially poorly followed at T0 but ultimately all reached moderate-to-high levels of application 5 months after the program. These included Q11—hydration, Q12—proper anchoring before projecting voice, and Q16.3—give short instructions, and four behaviors related to communication at distance: Q15.1—avoid shouting, Q15.2—use nonvocal tools, Q15.3—move to the child, or Q15.4—send another peer. Therefore, these behaviors should certainly be prioritized if the program content had to be limited to a select set of recommendations. The situation is less clear regarding other recommendations that were already frequently followed at T0 (Q10, Q13.1, Q13.3, Q13.4, and Q14.3). Since our study unfortunately did not include a baseline evaluation of these behaviors in the TEST group before receiving any prevention, or in the CTRL group that did not receive prevention, it remains uncertain whether the already high degree of application of these behaviors at T0 reflects their "natural" adoption by most individuals—without requiring recommendations from a prevention program—or if it indicates that they were very easily implemented immediately after the program. In that case, these behaviors would become even more important to prioritize in a prevention program than the seven preceding items, which showed more gradual improvement over time.

Finally, another interesting point to note is that almost all the recommendations either showed progress or were maintained over the five months following the preventive intervention. Moreover, the few that declined over time were still followed at moderate-to-high levels. In other words, none of the recommendations that had a moderate-to-high degree of application at T0 were ultimately abandoned or infrequently followed five months after the program. This raises the question of how durable behavioral change can be, how long the recommendations can be maintained, and, in particular, whether the positive impact would vanish as soon as the study—and the increased self-monitoring it requires from participants—comes to an end. Nonetheless, it is already very encouraging to observe that the effectiveness of preventive interventions in improving vocal behavior can last for at least five months. These results also suggest that "refresher sessions" throughout a teacher's career might be beneficial for maintaining the implementation of these recommendations.

Potential impact of self-reported behavior frequency on limiting the deterioration in vocal status

The significant behavioral changes observed, following the program's recommendations, provide initial support for the idea that the benefits of the preventive intervention on perceived vocal discomfort and difficulties may not be merely due to self-persuasion—such as the placebo effect that can occur with any therapeutic program, regardless of its content[73]—nor simply result from increased voice awareness and self-monitoring due to participation in a voice prevention program or even just from taking part in a scientific study on vocal usage and fatigue. The significant negative correlation observed between the self-reported frequency of certain behaviors and the level of self-reported vocal complaints or the acoustic changes following a workday provides further support for a possible causal link between following the program's recommendations and limiting the deterioration in vocal status.

Given this information, it seems relevant for future prevention programs to prioritize recommendations that not only show the most progress and retention over time but also have the greatest potential to prevent the deterioration in vocal status. Thus, among the seven behaviors previously identified as showing the most significant progress over time, only three (Q12—proper anchoring; Q15.3—move to the child; Q16.3—give short instructions) exhibited a significantly negative correlation between their frequency and the level of vocal complaints, suggesting that they may have a preventive impact. Therefore, they could be considered the top three most relevant recommendations to provide—and for participants to remember—in a voice prevention program. Conversely, while four other recommendations: Q11 (hydration), Q15.1 (avoid shouting to call a child), Q15.2 (use nonverbal tools to call a child), and Q15.4 (send another peer), also showed progress in application over time, they did not exhibit a significant correlation (of the expected direction) to support the idea that they had a notable impact on the participants' vocal health. As a result, it may finally be less relevant to include these recommendations—or at least to prioritize them—in future prevention programs.

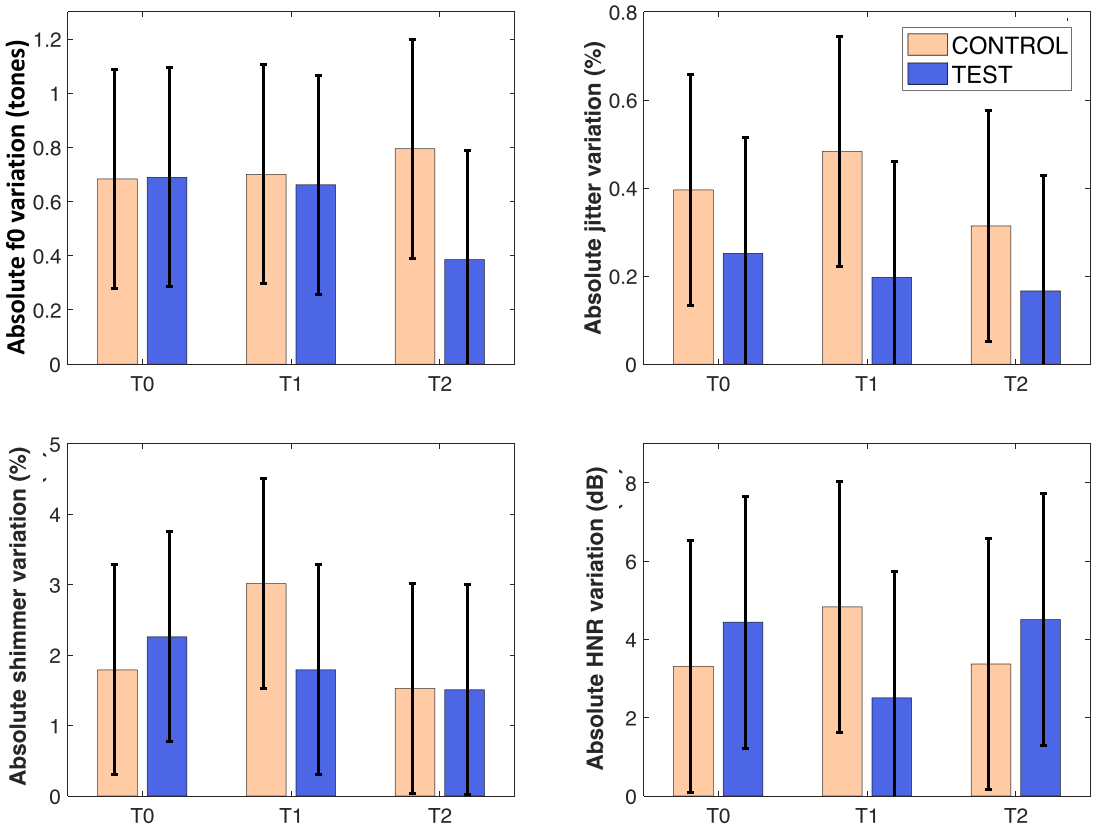

FIGURE 2. Absolute variation in f_0, jitter, shimmer, and HNR throughout a workday for the participants in both groups (TEST, CTRL) and across three times of the year, following the preventive intervention (T0: October, T1: December, and T2: February).

Conversely, among the behaviors that did not show significant progress over time, or even tended to decline—yet were still followed with a moderate-to-high frequency, five (Q10—vocal rest; Q13.3—crouch down; Q13.4—avoid speaking from the desk; Q16.2—ask another child to repeat instructions; Q17—active pedagogy) exhibited a significant correlation (of the expected direction) between their frequency and the level of vocal complaints, supporting the idea that they may be effective in preventing the deterioration in vocal status. As a result, it may also be relevant to provide or reinforce these recommendations in a prevention program, albeit as a secondary priority compared with the three top-priority recommendations (Q12, Q15.3, and Q16.3).

Limits and perspectives

These various results must be interpreted within the scope allowed by the experimental design of this study and its limitations.

First of all, this study is based on a relatively small cohort ($N = 22$), which is comparable to some previous studies[27,28,34,36,46,57–61] but smaller than others (over 150 participants in[19,29,49]). However, no previous study has yet provided, for a larger sample than ours and in a longitudinal design like ours, such a diverse and complementary set of measures—including acoustic measures, vocal self-assessments, and self-reported frequencies of various behaviors. Nevertheless, some trends observed in this study, which were on the verge of statistical significance, motivate the replication of the experiment with a larger cohort.

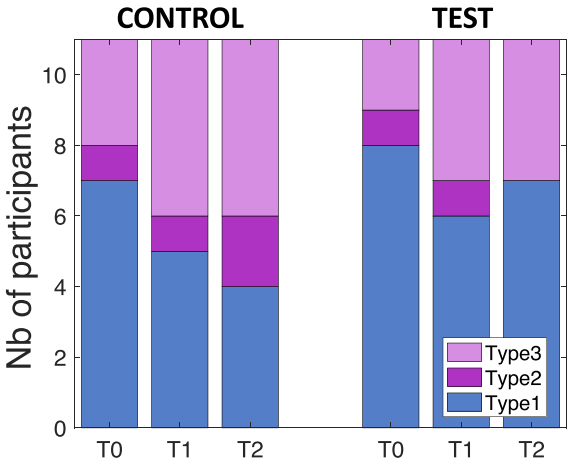

FIGURE 3. Number of participants presenting a profile of Type 1 (typical vocal response to a workday load), Type 2 (hyperfunctional), and Type 3 (possible inflammation or early signs of vocal lesions) in each group (TEST vs CTRL) and for each time of the year (T0: October, T1: December, and T2: February).

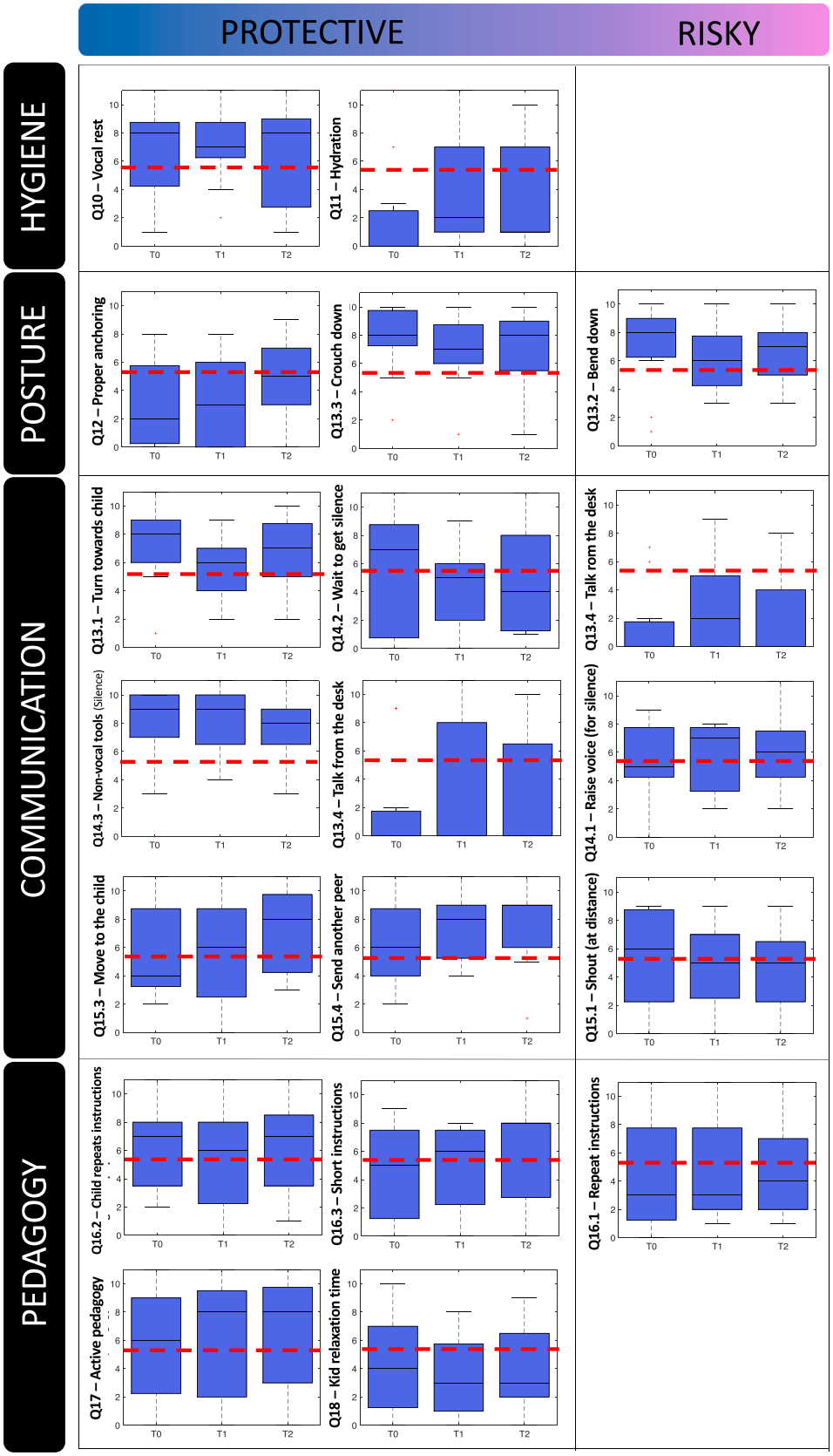

FIGURE 4. Variation in the self-reported frequency (from 0: never to 11: always) of several behaviors (protective or risky) throughout the year (T0: October, T1: December, and T2: February) for the group of participants who followed the preventive intervention (TEST). The red dashed line indicates an intermediate frequency score of 5.5.

Another limitation of our study—unfortunately shared by most other similar studies—is that testing the effectiveness of a prevention program would ideally require comparing a group that receives the program not only to a control with no prevention, but also to another group that receives a "placebo" program, ie, an intervention without any relevant recommendations (as in[42]). This would help assess whether the benefits of the prevention program truly stem from its content and the application of the provided recommendations, or simply from self-persuasion[2] of the time invested in the program, or increased voice awareness and self-monitoring due to participation in a scientific study.

A more concerning limitation of our study is that the first evaluation occurred immediately after the preventive intervention for the TEST group, so for these participants, we do not have any "Pre-Intervention" measures as a reference for their vocal status and behavior. As a result, some of the reported observations cannot be easily interpreted. In particular, it is unclear whether the lower level of vocal complaints and the more typical response profiles following a workday observed for the TEST group at T0, for some objective and subjective indicators, stems from a preexisting difference between the two groups—although we controlled for the absence of preexisting voice disorders during the inclusion phase—or if this lower level reflects immediate benefits of the program. Similarly, it is unclear whether the high frequency of some protective behaviors observed in the TEST group at T0 reflects immediate application of the preventive program, or if these behaviors were already "naturally" adopted by most individuals without the need for recommendation.

In line with this, another important limitation of our study is that we evaluated the (self-reported) frequency of various behaviors, both protective or risky, only for the TEST group that received the preventive recommendations. In hindsight, it would have been very useful to have similar measures for the CTRL group as well, in order to examine and discuss the extent to which these recommendations are based on "common sense" and already intuitively followed by individuals, or whether the preventive intervention provides the teachers with new and nontrivial information.

Other details of the experimental design can also be debated and would certainly be worth improving in a future study. Thus, although the first short questionnaire on self-reported vocal complaints was relevant—having been developed in collaboration with speech therapists and a phoniatrician (in French), and inspired by questionnaires used in previous other studies[25,26,28,29,42,49,50,62]—it would be interesting to incorporate longer validated questionnaires such as the VHI, VFI, the VRQL, World Health Organization Quality of Life, VoiSC, or VDI-10 (not all of which are currently available in French), to allow comparison with normative data. This would facilitate comparison between studies and enable meta-analyses of their results. Furthermore, the second questionnaire on self-assessment of various behavior frequencies would benefit from further development, covering more systematically all the recommendations provided during the preventive intervention regarding vocal hygiene, vocal technique, breathing and posture, and communicative and pedagogical strategies. In line with this, it would undoubtedly be interesting to compare these introspective self-assessments of behavior frequency with evaluations by an external observer, based, for example, on video recordings of teachers in their classrooms.

Finally, additional analyses would be needed to further explore the extent to which vocal complaints and acoustic changes following a workday can be predicted by the frequency of various behaviors. In particular, as in the study of drug interactions, it may be insightful to consider the individual's vocal behavior as a whole and use multiparametric analysis to examine how different protective behaviors may have a positive impact only when adopted together, or conversely, how the benefits of certain protective behaviors may be hindered if one specific "negative" behavior is still followed more than moderately.

CONCLUSION

Despite these limitations and areas for improvement, the study provides new and complementary insights into voice prevention. In particular, the comparison of subjective and objective measures of vocal status in a longitudinal design, along with the evaluation of the frequency of various behaviors (protective or risky), enabled us to assess the effectiveness of a one-day voice preventive intervention. In addition to previous studies, this effectiveness was evaluated here not only in terms of limiting the deterioration in vocal status throughout the year, but also in terms of application and retention of the provided recommendations. Correlation analysis between the frequency of these behaviors and the level of vocal complaints provided preliminary evidence supporting the varying preventive impact they may have. This provides new insights into the design of future prevention programs, particularly by prioritizing recommendations that appear to significantly impact vocal status and show the most progress in application over time (Q12—proper anchoring before projecting voice; Q15.3—move to the child to call him at distance; Q16.3—give short instructions).

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships that may be considered as potential competing interests: Maeva GARNIER reports administrative support was provided by General Mutual of National Education (MGEN). Maeva GARNIER reports administrative support was provided by Grenoble's school academy. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting Information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jvoice.2025.07.010.

References

1. Autesserre D, Charpy N, Crevier-Buchman L, et al. La voix: ses troubles chez les enseignants. [Voice disorders in teachers], INSERM report: 2006. Available at: https://hal-lara.archives-ouvertes.fr/hal-01570681/.
2. Titze IR, Lemke J, Montequin D. Populations in the US workforce who rely on voice as a primary tool of trade: a preliminary report. *J Voice.* 1997;11:254–259.
3. Remacle A, Petitfils C, Finck C, Morsomme D. Description of patients consulting the voice clinic regarding gender, age, occupational status, and diagnosis. *Eur Arch Otorhinolaryngol.* 2017;274:1567–1576.
4. Van Houtte E, Van Lierde K, D'haeseleer E, Claeys S. The prevalence of laryngeal pathology in a treatment-seeking population with dysphonia. *Laryngoscope.* 2010;120:306–312.
5. Roy N, Merill R, Thibeault S, Parsa R, Gray S, Smith E. Prevalence of voice disorders in teachers and general population. *J Speech Lang Hear Res.* 2004;47:281–293.
6. Sliwinska-Kowalska M, Niebudek-Bogusz E, Fiszer M, et al. The prevalence and risk factors for occupational voice disorders in teachers. *Folia Phoniatr Logop.* 2006;58:85–101.
7. Smith E, Gray SD, Dove H, Kirchner L, Heras H. Frequency and effects of teachers' voice problems. *J Voice.* 1997;11:81–87.
8. Smith E, Lemke J, Taylor M, Kirchner HL, Hoffman H. Frequency of voice problems among teachers and other occupations. *J Voice.* 1998;12:480–488.
9. Coyle SM, Weinrich BD, Stemple JC. Shifts in relative prevalence of laryngeal pathology in a treatment-seeking population. *J Voice.* 2001;15:424–440.
10. Chen SH, Chiang SC, Chung YM, Hsiao LC, Hsiao TY. Risk factors and effects of voice problems for teachers. *J Voice.* 2010;24:183–192.
11. Roy N. Voice disorders in teachers. *Perspect Voice Voice Disord.* 2011;21:71–79.
12. Morton V, Watson DR. The impact of impaired vocal quality on children's ability to process spoken language. *Logoped Phoniatr Vocol.* 2001;26:17–25.
13. Rogerson J, Dodd B. Is there an effect of dysphonic teachers' voices on children's processing of spoken language? *J Voice.* 2005;19:47–60.
14. Schiller IS, Morsomme D, Kob M, Remacle A. Listening to a dysphonic speaker in noise may impede children's spoken language processing in a realistic classroom setting. *Lang Speech Hear Serv Sch.* 2021;52:396–408.
15. Schiller IS, Morsomme D, Kob M, Remacle A. Noise and a Speaker's impaired voice quality disrupt spoken language processing in school-aged children: evidence from performance and response time measures. *J Speech Lang Hear Res.* 2020;63:2115–2131.
16. Chui JCH, Ma EPM. The impact of dysphonic voices on children's comprehension of spoken language. *J Voice.* 2019;33:801-e7.
17. Schiller IS, Remacle A, Durieux N, Morsomme D. Effects of noise and a speaker's impaired voice quality on spoken language processing in school-aged children: a systematic review and meta-analysis. *J Speech Lang Hear Res.* 2022;65:169–199.
18. Van Stan JH, Roy N, Awan S, Stemple J, Hillman RE. A taxonomy of voice therapy. *Am J Speech Lang Pathol.* 2015;24:101–125.
19. Bolbol SA, Zalat MM, Hammam RA, Elnakeb NL. Risk factors of voice disorders and impact of vocal hygiene awareness program among teachers in public schools in Egypt. *J Voice.* 2017;31:251-e9.
20. Boominathan P, Chandrasekhar D, Nagarajan R, Madraswala Z, Rajan A. Vocal hygiene awareness program for professional voice users (Teachers): an evaluative study from Chennai. *Asia Pac J Speech Lang Hear.* 2008;11:39–45.
21. Chan KM, Yiu EML. Green voice project: preserving the healthy voice in teachers. *SIG 3 Perspect Voice Voice Disord.* 2011;21:62–70.
22. Duffy OM, Hazlett DE. The impact of preventive voice care programs for training teachers: a longitudinal study. *J Voice.* 2004;18:63–70.
23. Faham M, Ahmadi A, Drinnan M, Saadatmand N, Fatahi E, Jalalipour M. The effects of a voice education program on VHI scores of elementary school teachers. *J Voice.* 2016;30:755-e1.
24. Hackworth RS. The effect of vocal hygiene and behavior modification instruction on the self-reported vocal health habits of public school music teachers. *Int J Music Educ.* 2007;25:20–28.
25. Ilomäki I, Laukkanen AM, Leppänen K, Vilkman E. Effects of voice training and voice hygiene education on acoustic and perceptual speech parameters and self-reported vocal well-being in female teachers. *Logoped Phoniatr Vocol.* 2008;33:83–92.
26. Leppänen K, Laukkanen AM, Ilomäki I, Vilkman E. A comparison of the effects of voice massage™ and voice hygiene lecture on self-reported vocal well-being and acoustic and perceptual speech parameters in female teachers. *Folia Phoniatr Logop.* 2009;61:227–238.
27. Nanjundeswaran C, Li NY, Chan KM, Wong RK, Yiu EML, Verdolini-Abbott K. Preliminary data on prevention and treatment of voice problems in student teachers. *J Voice.* 2012;26:816-e1.
28. Pasa G, Oates J, Dacakis G. The relative effectiveness of vocal hygiene training and vocal function exercises in preventing voice disorders in primary school teachers. *Logoped Phoniatr Vocol.* 2007;32:128–140.
29. Pemberton C, Oates J, Russell A. Voice care education: preliminary evaluation of the Voice Care for Teachers package. *J Health Saf Environ.* 2010;26:441–462.
30. Pizolato RA, Beltrati Cornacchioni Rehder MI, dos Santos Dias CT, et al. Evaluation of the effectiveness of a voice training program for teachers. *J Voice.* 2013;27:603–610.
31. Pizolato RA, Rehder MIBC, de Castro Meneghim M, Ambrosano GMB, Mialhe FL, Pereira AC. Impact on quality of life in teachers after educational actions for prevention of voice disorders: a longitudinal study. *Health Qual Life Outcomes.* 2013;11:1.
32. Roy N, Gray SD, Simon M, Dove H, Corbin-Lewis K, Stemple JC. An evaluation of the effects of two treatment approaches for teachers with voice disorders. *J Speech Lang Hear Res.* 2001;44:286–296.
33. Roy N, Weinrich B, Gray SD, et al. Voice amplification versus vocal hygiene instruction for teachers with voice disorders. *J Speech Lang Hear Res.* 2002;45:623–638.
34. Santana É.R, Masson MLV, Araújo TM. The effect of surface hydration on teachers' voice quality: an intervention study. *J Voice.* 2017;31:383-e5.
35. Karatayli Ozgursoy S, Buyukatalay ZÇ, Dursun G. The effect of vocal hygiene training via videoconference in teachers' voices. *J Voice.* 2024;38:e17–e26.
36. Chan RWK. Does the voice improve with vocal hygiene education? A study of some instrumental voice measures in a group of kindergarten teachers. *J Voice.* 1994;8:279–291.

37. de Oliveira Bastos PRH, Hermes EC. Effectiveness of the teacher's vocal health program (TVHP) in the municipal education network of Campo Grande, MS. *J Voice.* 2018;32:681–688.
38. Stemple JC. A holistic approach to voice therapy. *Semin Speech Lang.* 2005;26:131–137.
39. Yiu EML, Lo MC, Barrett EA. A systematic review of resonant voice therapy. *Int J Speech Lang Pathol.* 2017;19:17–29.
40. Kotby MN, Shiromoto O, Hirano M. The accent method of voice therapy: effect of accentuations on FO, SPL, and airflow. *J Voice.* 1993;7:319–325.
41. Bovo R, Galceran M, Petruccelli J, Hatzopoulos S. Vocal problems among teachers: evaluation of a preventive voice program. *J Voice.* 2007;21:705–722.
42. McCabe DJ, Titze IR. Chant therapy for treating vocal fatigue among public school teachers: a preliminary study. *Am J Speech Lang Pathol.* 2002;11:356–369.
43. Nguyen DD, Kenny DT. Randomized controlled trial of vocal function exercises on muscle tension dysphonia in Vietnamese female teachers. *J Otolaryngol Neck Surg.* 2009;38:261–278.
44. Roy N, Weinrich B, Gray SD, Tanner K, Stemple JC, Sapienza CM. Three treatments for teachers with voice disorders. *J Speech Lang Hear Res.* 2003;46:670–688.
45. Mailaender E, Mühre L, Barsties B. Lax Vox as a voice training program for teachers: a pilot study. *J Voice.* 2017;31:262-e13.
46. Chen SH, Hsiao TY, Hsiao LC, Chung YM, Chiang SC. Outcome of resonant voice therapy for female teachers with voice disorders: perceptual, physiological, acoustic, aerodynamic, and functional measurements. *J Voice.* 2007;21:415–425.
47. Jalowska M, Woskowiak G, Wiskirska-Woznica B. Evaluation of the results of the prevention program "Protect your voice" implemented by the Greater Poland Center of Occupational Medicine of Poznan. *Med Pr.* 2017;68:593–604.
48. Duan J, Zhu L, Yan Y, Pan T, Lu P, Ma F. The efficacy of a voice training program: a case–control study in China. *Eur Arch Otorhinolaryngol.* 2010;267:101–105.
49. Niebudek-Bogusz E, Sznurowska-Przygocka B, Fiszer M, et al. The effectiveness of voice therapy for teachers with dysphonia. *Folia Phoniatr Logop.* 2008;60:134–141.
50. Simberg S. Prevalence of vocal symptoms and voice disorders among teacher students and teachers and a model of early intervention. 2004; Doctoral dissertation, University of Helsinki.
51. Remacle A, Bouchard S, Morsomme D. Can teaching simulations in a virtual classroom help trainee teachers to develop oral communication skills and self-efficacy? A randomized controlled trial. *Comput Educ.* 2023;200:104808.
52. Lopez JM, Catena A, Montes A, Castillo ME. Effectiveness of a short voice training program for teachers: a preliminary study. *J Voice.* 2017;31:697–706.
53. Richter B, Nusseck M, Spahn C, Echternach M. Effectiveness of a voice training program for student teachers on vocal health. *J Voice.* 2016;30:452–459.
54. Timmermans B, Coveliers Y, Meeus W, Vandenabeele F, Van Looy L, Wuyts F. The effect of a short voice training program in future teachers. *J Voice.* 2011;25:e191–e198.
55. Timmermans B, Coveliers Y, Wuyts FL, Van Looy L. Voice training in teacher education: the effect of adding an individualized microteaching session of 30 min to the regular 6-hour voice training program. *J Voice.* 2012;26:669-e1.
56. Nusseck M, Immerz A, Spahn C, Echternach M, Richter B. Long-term effects of a voice training program for teachers on vocal and mental health. *J Voice.* 2021;35:438–446.
57. Grillo EU. An online telepractice model for the prevention of voice disorders in vocally healthy student teachers evaluated by a smartphone application. *Perspect ASHA Spec Interest Groups.* 2017;2:63–78.
58. Amir O, Dukas M, Shnaps-Baum R. The effect of a "voice course" on the voices of people with and without pathologies: preliminary observations. *Logoped Phoniatr Vocol.* 2005;30:63–71.
59. Cavalcanti NR, Souza BO, Gama ACC, Medeiros AM de. *Effect of the comprehensive voice rehabilitation program in teachers with behavioral dysphonia. CoDAS.* Brasil: SciELO,; 2018.
60. Silverio KCA, Gonçalves CGDO, Penteado RZ, Vieira TPG, Libardi A, Rossi D. Actions in vocal health: a proposal for improving the vocal profile of teachers. *Pró-Fono Rev Atualização Científica.* 2008;20:177–182.
61. Gillivan-Murphy P, Drinnan MJ, O'Dwyer TP, Ridha H, Carding P. The effectiveness of a voice treatment approach for teachers with self-reported voice problems. *J Voice.* 2006;20:423–431.
62. Ilomäki I, Mäki E, Laukkanen AM. Vocal symptoms among teachers with and without voice education. *Logoped Phoniatr Vocol.* 2005;30:171–174.
63. Hunter EJ, Banks RE. Gender differences in the reporting of vocal fatigue in teachers as quantified by the vocal fatigue index. *Ann Otol Rhinol Laryngol.* 2017;126:813–818.
64. Thomas G, de Jong FI, Cremers CWRJ, Kooijman PGC. Prevalence of voice complaints, risk factors and impact of voice problems in female student teachers. *Folia Phoniatr Logop.* 2006;58:65–84.
65. Kooijman PG, Thomas G, Graamans K, De Jong F. Psychosocial impact of the teacher's voice throughout the career. *J Voice.* 2007;21:316–324.
66. Sodersten M, Granqvist S, Hammarberg B, Szabo A. Vocal behavior and vocal loading factors for preschool teachers at work studied with binaural DAT recordings. *J Voice.* 2002;16:356–371.
67. Remacle A, Morsomme D, Finck C. Comparison of vocal loading parameters in kindergarten and elementary school teachers. *J Speech Lang Hear Res.* 2014;57:406–415.
68. Martins RHG, Pereira ERBN, Hidalgo CB, Tavares ELM. Voice disorders in teachers. A review. *J Voice.* 2014;28:716–724.
69. Remacle A, Lefèvre N. Which teachers are most at risk for voice disorders? Individual factors predicting vocal acoustic parameters monitored in situ during a workweek. *Int Arch Occup Environ Health.* 2021;94:1271–1285.
70. Smith E, Kirchner HL, Taylor M, Hoffman H, Lemke JH. Voice problems among teachers: differences by gender and teaching characteristics. *J Voice.* 1998;12:328–334.
71. Richter B, Nusseck M, Spahn C, Echternach M. Effectiveness of a voice training program for student teachers on vocal health. *J Voice.* 2016;30:452–459.
72. Van Stan JH, Maffei M, Masson MLV, Mehta DD, Burns JA, Hillman RE. Self-ratings of vocal status in daily life: reliability and validity for patients with vocal hyperfunction and a normative group. *Am J Speech Lang Pathol.* 2017;26:1167–1177.
73. Linde K, Fässler M, Meissner K. Placebo interventions, placebo effects and clinical practice. *Philos Trans R Soc B Biol Sci.* 2011;27:1905–1912.
74. Fritzell B. Voice disorders and occupations. *Logoped Phoniatr Vocol.* 1996;21:7–12.
75. Thibeault SL, Merrill RM, Roy N, Gray SD, Smith EM. Occupational risk factors associated with voice disorders among teachers. *Ann Epidemiol.* 2004;14:786–792.
76. Benson EA. The Estill voice model: theory and translation. *Voice Speech Rev.* 2017;11:112–114.
77. Boersma P. Praat: doing phonetics by computer. 2022. [Computer program]. Version 6.2.06. Available at: http://www.praat.org.
78. Remacle A, Garnier M, Gerber S, David C, Petillon C. Vocal change patterns during a teaching day: inter- and intra-subject variability. *J Voice.* 2018;3 2:57–63.
79. R Core Team. *R: A Language and Environment for Statistical Computing.* Vienna, Austria: R Foundation for Statistical Computing,; 2022.
80. Leppänen K, Laukkanen AM, Ilomäki I, Vilkman E. A comparison of the effects of voice massage™ and voice hygiene lecture on self-

reported vocal well-being and acoustic and perceptual speech parameters in female teachers. *Folia Phoniatr Logop.* 2009;61:227–238.
81. Ilomäki I, Laukkanen AM, Leppänen K, Vilkman E. Effects of voice training and voice hygiene education on acoustic and perceptual speech parameters and self-reported vocal well-being in female teachers. *Logoped Phoniatr Vocol.* 2008;33:83–92.
82. Nusseck M, Immerz A, Spahn C, Echternach M, Richter B. Long-term effects of a voice training program for teachers on vocal and mental health. *J Voice.* 2021;35:438–446.
83. Grillo EU. An online telepractice model for the prevention of voice disorders in vocally healthy student teachers evaluated by a smartphone application. *Perspect ASHA Spec Int Groups.* 2017;2:63–78.