

Four-day Follow-up Study on the Self-reported Voice Condition and Noise Condition of Teachers: Relationship Between Vocal Parameters and Classroom Acoustics

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Summary: Objectives. This study aimed to determine the changes in self-reported voice and noise condition over a follow-up of 4 days (equivalent to one working week), to define the relationship between the objective voice parameters and the self-reported voice condition, as well as to characterize the relationship between classroom acoustics and the self-reported noise condition.

Study design. This is a cohort study.

Methods. We performed voice monitoring of 27 teachers for four working days using the Voice-Care device, which provides information on the fundamental frequency, vocal sound pressure level, and phonation time percentage. The participants performed a pre-monitoring, which consisted of a brief conversation, before each monitoring session, and filled in a questionnaire after each monitored lesson, in which they indicated their opinions about their voice condition and the classroom noise conditions.

Results. The teachers who, during the pre-monitoring, showed a higher standard deviation of the vocal sound pressure level and a greater phonation time percentage difference between the entire monitoring and the pre-monitoring sessions, reported fewer voice complaints. Decay time (DT_{40ME}), a reverberation measure from the speakers' perspective, resulted to be associated with the self-reporting of the noise condition.

Conclusion. Voice disorders at work prevention programs should include strategies to exercise the respiratory and laryngeal components of voice production, because these elements may influence the variation in the vocal sound pressure level, which was found to be significantly associated with the self-reported voice condition. This study also highlights the importance of including reverberation measures, from the speakers' perspective, in the design of schools.

Key Words: voice disorders—objective voice analysis—self-report—classroom acoustics—teacher.

INTRODUCTION

Voice disorders are well-known health problems among teachers. Although previous research has shown that the occurrence of voice disorders is significantly higher among teachers than in other occupations, the reported prevalence seems to differ to a great extent.¹⁻³ This wide range of prevalence can in part be explained by considering the different assessment methods that are used to determine the presence of voice disorders.¹ Previous research, which relied exclusively on questionnaires, reported a 12-month prevalence of up to 80%,⁴ whereas studies that reported information on objective voice assessments reported a prevalence of up to 57%.⁵

Because most studies on voice disorders among teachers have based their results on questionnaires,¹ it is important to determine to what extent the self-assessment of voice quality, by means of questionnaires, is associated with objective voice parameters, such as the fundamental frequency or the vocal sound

pressure level. Improving the knowledge about this relationship will allow the health-care providers of teachers to design and implement efficient protocols for the assessment of work-related voice disorders.

To the best of the authors' knowledge, the previous cross-sectional studies that investigated associations between self-reporting and objective voice assessments among teachers gave conflicting results. Rantala and Vilkmann reported significant associations between both the fundamental frequency and sound pressure level and the self-reported voice complaints, with correlation coefficients of around 0.6.⁶ Bottalico and Astolfi found a positive correlation between self-reported "voice intensity" and mean vocal sound pressure level values during traditional lessons.⁷ Nevertheless, other studies have failed to confirm these findings. Laukkanen et al reported no correlations between the means of the fundamental frequency, sound pressure level and alpha ratio, and self-reported vocal fatigue,⁸ whereas Ilomaki et al and Kankare et al reported no correlation between clinical assessments and self-reported voice conditions.^{9,10}

Moreover, some studies have reported changes in the fundamental frequency and the higher spectral components during both the first and the last lessons of a working day,^{11,12} but there is a lack of evidence about the changes and associations of self-reporting and objective voice parameters monitored during longer working periods (for instance, a week).

A couple of previous studies assessed the relationship between the self-reporting of the noise condition and the classroom

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acoustic parameters, and presented contradictory findings. Bottalico and Astolfi reported significant differences in the “perceived noise intensity scores” between teachers who worked in classrooms with long reverberation times and teachers who worked in classrooms with short reverberation times.⁷ On the other hand, Cantor Cutiva and Burdorf found no differences in the mean noise level and reverberation time values between teachers who reported uncomfortable acoustic conditions and those who reported comfortable acoustic conditions inside classrooms.¹³ The relationship between self-reporting of noise condition and classroom acoustics still has to be determined, and this could hamper the definition of the influence of the working environment and of individual sensitivity on the occurrence of voice disorders among teachers.

Therefore, a 4-day follow-up study has been conducted with three aims: (1) to determine the changes in self-reported voice and noise conditions over a 4-day follow-up period, (2) to define the relationship between the objective voice parameters monitored over a period of up to 4 hours of lessons and the self-reported voice condition, and (3) to characterize the relationship between classroom acoustics and the self-reported noise condition.

METHODS

Design and participants

At the end of the 2013 and 2014 academic years, the head teachers of four primary schools, located in the provinces of Turin and Bolzano (Italy), took part in meetings with the researchers involved in the present research to discuss the purpose and requirements of this study and to establish their willingness to participate. After the approval of the head teacher of each school, the researchers visited the schools to contact and inform the teachers about the aims of the study and to explain the voluntary nature of participation. The teachers who were interested in participating in the study then scheduled the date and time of each monitoring session. A total of 16 teachers in May 2013 and 11 teachers in April 2014 agreed to take part. Among the 27 primary school teachers, vocal monitoring was carried out over a period of up to four working days, from Monday to Thursday. This study complied with the ethical principles outlined in the Declaration of Helsinki.

Data collection procedures

Short questionnaire filled in daily

A self-administered questionnaire, based on an already existing English-language questionnaire described in a previous study,¹⁴ was adopted in this study. This questionnaire was filled in after each monitored lesson (up to 4 hours), and consisted of seven questions that allowed information to be collected on three main aspects: (1) individual characteristics, such as gender and age; (2) voice condition; and (3) work-related conditions in terms of years on teaching, subject taught, type of lesson, and noise condition.

Voice condition. In this study, the question in the second section of the questionnaire was used to determine the “voice condition.” The teachers were asked to rate the status of their

voice at the end of the monitored lesson and compare it with their voice at the beginning of their working day. They were asked to rate their voice by marking an “X” in a continuous horizontal line about 10 cm long, where the extreme left of the line represented *no voice problem* and the extreme right indicated *severe voice problem*.

Work-related conditions. Four questions from the third section of the questionnaire were used to determine the working conditions. The years of teaching and subject taught were open questions. The subject taught was considered a dichotomous variable (scientific and humanities) for further analysis, with teachers who reported teaching mathematics, physics, sciences, chemistry, or informatics considered as teachers of scientific subjects, whereas teachers who reported teaching languages (Italian or English) and religion were defined as teachers of humanities.

The noise condition was defined by asking the teachers to rate the degree of noise during the lesson inside the classroom and compare it with the noise of non-occupied classroom and school at the beginning of the working day. The teachers were asked to indicate whether they considered the classrooms very noisy by marking an “X” on a continuous horizontal line about 10 cm long. The extreme left of the line indicated *very low* and the extreme right indicated *very high*.

Voice monitoring

The voice monitoring of the participating teachers was carried out for up to four consecutive working days using the Voice-Care device (P.R.O.VOICE S.r.l, Turin, Italy). This device consists of a data logger connected to an electret condenser microphone (ECMAE38; Alan Electronics GmbH, Dreieich, Germany), which was placed at the speaker’s jugular notch.¹⁵ The Voice-Care device (a vocal dosimeter) provides information on the fundamental frequency, phonation time percentage, and vocal sound pressure level. Phonation time percentage is defined as the percentage of time spent phonating over the total recording time.¹⁶

To accurately estimate the vocal sound pressure level, it is necessary to perform a calibration process. This calibration process was carried out in a quiet room in each school, using a reference microphone (Behringer HM-8000; MUSIC Group, Makati, Philippines) positioned 16 cm from the speaker’s mouth, to correlate the vocal sound pressure level recorded by the microphone to the skin acceleration level induced by the vocal fold vibration, detected by means of the Voice-Care device. For this calibration process, the teachers were asked to repeatedly pronounce the vowel [a] at increasing levels of intensity.¹⁷ The vocal sound pressure level was defined, for further analysis, at a distance of 16 cm from the speaker’s mouth, as the vocal sound pressure level mouth-to-microphone distance.¹⁸

The voice monitoring of the participating teachers was analyzed under two different conditions in this study. First, after the calibration process and before each monitoring session, the participants were asked to perform a conversational task (pre-monitoring). For this task, the teachers were asked to speak to a listener, positioned at a distance of 1 m, about a topic that was well known to them (for instance, the way to get home from school, the topic of the lesson/one of the lessons of that day, etc)

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