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Noise Exposure of Music Teachers

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A noise exposure survey was performed to assess the risk of hearing loss to school music teachers during the course of their activities. Noise exposure of 18 teachers from 15 schools was measured using noise dosimeters. The equivalent continuous noise level (L_{eq}) of each teacher was recorded during single activities (classes) as well as for the entire day, and a normalized 8-hour exposure, termed the noise exposure level (L_{ex}) was also computed. The measured L_{eq} exceeded the 85-dBA limit for 78% of the teachers. L_{ex} exceeded 85 dBA for 39% of the teachers. Limited recommendations on how to reduce the noise exposures are provided. The need for a hearing conservation program has also been emphasized.

Keywords hearing conservation, noise exposure, school music teachers

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INTRODUCTION

A study of the noise exposure of public school music teachers was performed with the objective of determining the risk of hearing loss. This article describes the objectives of the study, measuring methods used, and results and interpretation of the measurements, as well as recommendations regarding corrective measures that can reduce teachers' risk of hearing loss.

Music teachers are exposed to a number of noise sources during the course of their activities. They teach the playing of instruments and conduct bands and choirs. The size and activities of their classes vary greatly, as do the noise levels to which they are exposed.

Noise exposure can be classified as "occupational" since it is generated as a result of the teachers' occupation. Although students are also exposed to the same or even higher noise levels while playing or singing, the duration of their noise exposure is much shorter than that of the teachers. On a given day a student may be exposed to high noise levels for only one music class, while a teacher can be exposed to high levels for many class periods. Consequently, the risk of hearing loss due to noise exposure in music classrooms may be potentially significant for teachers but not as likely for students.

There is an abundance of literature dealing with the risk of hearing loss in musicians. However, there is very little data regarding the exposure of conductors of music ensembles or of teachers in the school environment. The only study of teachers' noise exposure we are aware of was performed in British Columbia[(1)] where, for a small sample size ($n = 10$), it was concluded that there is a potential risk of hearing loss. Other papers containing similar information have been published elsewhere.[(2–4)]

A likely reason for the lack of similar studies is the difficulty in determining a teacher's "typical" day or week. The distribution of activities varies greatly from teacher to teacher (even in the same school), from day to day, and from week to week. Extra-curricular activities such as competitions, school acts, or musicals, requiring band, orchestra, and/or choir rehearsals add to the noise exposure. While this added noise exposure might not be in the classroom proper, it still contributes to the total occupational noise exposure of the teacher.

The present study was based on measuring noise exposure levels from single activities (classes) such as rehearsing a band or teaching music theory. The choice to focus on a particular activity was motivated by the difficulty in determining a "typical" day for that activity. The physical environment (acoustic characteristics of each room), duration of activity, and the number of students involved were recorded and taken into account. With the knowledge of the average noise exposure for a particular activity and the total duration of activities in an average day or week, it is possible to estimate daily or weekly noise exposure levels. The corresponding calculation is shown further in the text.

Another objective of the study was to provide recommendations on how the risk of hearing loss could be reduced using hearing protectors and/or implementing a hearing conservation program. The estimate of the risk of hearing loss adopted for this study was the equivalent continuous noise level (L_{eq}), measured in dBA. It is defined as the constant noise level that would provide an equal amount of sound energy over the measurement period. Thus, it can be interpreted loosely as a measure of the acoustical energy entering the exposed individuals' ears. L_{eq} was measured using dosimeters and following the procedures stated in the Canadian Standards Association (CSA) Standard Z107.56-94.(5)

Another estimate used in this study was the noise exposure level, L_{ex} (also expressed in dBA). The L_{ex} is normalized over an 8-hour period assuming that during the rest of the day (the difference between the measurement duration and the 8-hour workday), the person remains in a quiet environment, which for the purpose of this study had a sound level <70 dBA, where no hearing loss may occur. It is calculated from the measured L_{eq} averaged over an 8-hour period of time as $L_{ex} = L_{eq} + 10 \text{ Log } t/8$, where t is the time the L_{eq} was measured. For example, if in a given situation, the L_{eq} that was measured for 4 hours was 85 dBA and less than 70 dB during the remaining 4 hours, the resulting 8-hour L_{ex} would be 82 dBA.

Finally, the measurement error of L_{eq} was estimated as ± 2 dB for field sound level measurements.(6) The same order of error should be associated with noise exposure measurements. For that reason exposure values in this article have been rounded to the nearest integer.

Risk Criteria

In Canada there is no federal or provincial legislation specifically regarding teachers' maximum daily noise exposure. The Ontario Occupational Health and Safety Act and Regulations for Industrial Establishments(7) that applies to most occupations specifies that the maximum daily exposure level should not exceed 90 dBA, a limit that increases by 5 dBA every time the length of the exposure is halved (5-dB exchange rate). This criterion is also used by the Occupational Safety and Health Administration (OSHA) in the United States and the result is expressed as L_{OSHA}.

Another widely accepted criterion establishes a daily 8-hour exposure limit of 85 dBA and uses a 3-dB exchange rate. This criterion, used in most provinces in Canada, is also recommended by several institutions in the United States (e.g., the National Institute for Occupational Safety and Health [NIOSH],(8) the American Conference of Governmental Industrial Hygienists [ACGIH],(9) and the International Organization for Standardization [ISO]) and is used in most countries in Europe. This is also the criterion used in this report for measurements as well as for the assessment of the risk of hearing loss.

Participants

Noise exposures were measured on 18 music teachers from 15 different public schools from the same board of education. They all volunteered for the study. A flyer was sent to all music teachers in the board requesting their participation. The flyer indicated (1) participants would have to wear a noise dosimeter while performing their normal tasks, and (2) individual data would be kept confidential.

There were no specific limitations for the volunteers such as minimum hearing level at various frequencies, age, sex, or length of service. The objective of the study and the measurement procedure were explained to all participants. The teachers were also advised that the study was anonymous and that their names would not be disclosed.

Instrumentation

Measurements were performed using Quest Q-300 dosimeters, and following the procedures in the CSA Standard Z107.56-94.(5) Dosimeters were set to measure "slow." The L_{eq} was set within the range 40–110 dBA.

Dosimeters were calibrated in the field, using a Quest QC-10 sound calibrator, following the procedure recommended by the manufacturer. A B&K Model 2231 Modular Precision Sound Level Meter was also used to spot check the results from the dosimeters.

Results of the measurements were recorded on the spot and discussed with the person wearing the dosimeter.

Back in the laboratory, the information stored in the memory of the dosimeters was extracted and recorded using the Quest-Suite Professional computer program.(10) The same program was used for setting the dosimeters and for checking their calibration.

METHODS

Each volunteer who answered the flyer was contacted individually to set a date for the test. On the agreed day, one or two members of the team arrived at the school before the beginning of the class to meet the teacher and explain again the objective of the test and the measurement procedure, which can be summarized as follows:

- The teacher was fitted with the dosimeter and was instructed to wear the dosimeter during the entire test period (between half a day and an entire day, depending of the teacher's schedule for the day).
- The dosimeter was collected at the end of the measurement period.
- The teacher was then informed about the measured L_{eq}, and questions were answered regarding the significance of the result.

Members from the team followed the teacher during the measurement period taking spot sound level measurements and registering the activities being performed and their duration. Data of the acoustical characteristics of the environment were also collected.

Once in the laboratory, the logged data as well as the results from the questionnaire were downloaded into a database.

TABLE I. L_{eq} and L_{ex} of Music Teachers

Teacher	Measured L_{eq} (dBA)	Measured Duration, Hr	Calculated L_{ex} (dBA)
1	89	5	87
2	91	5	89
3	89	3	85
4	95	5	93
5	88	4	85
6	82	4	79
7	90	3	86
8	88	4	85
9	82	7	82
10	86	6	85
11	88	3	84
12	82	5	80
13	88	4	85
14	87	3	82
15	92	7	92
16	93	5	91
17	85	4	82
18	87	4	84

RESULTS

L_{eq} and L_{ex}

Table I shows the measured L_{eq}, the measurement duration, and the calculated 8 hour L_{ex}. Results show that the measured L_{eq} exceeded the 85 dBA limit on 14 occasions (78%). On only four occasions (22%) was the measured L_{eq} at or under 85 dBA. Also, the limit for the calculated L_{ex} exceeded 85 dBA for 7 teachers (39%), while it was at or under this limit for 11 (61%) of them.

L_{eq} Per Activity

Table II summarizes the results, providing the mean value of the measured L_{eq} per activity (singing, percussion, keyboard, recorder, and band) and per type of school. In this table the public, middle, and elementary schools have been grouped together as "Elementary." Mean, standard deviation, and range were calculated for the activities where there was a significant number of samples. For the calculation, it was assumed that all samples were normally distributed.

No noticeable difference was found between the mean L_{eq} from elementary or secondary schools. It appears that the noise exposure levels are mostly dependent on the type of music being performed, not on the musicians' skill.

From the results it appears that band, singing, and recorder are activities that are most likely to result in excessive noise exposure. Only keyboards have a mean L_{eq} that is less than 85 dBA.

From the mean L_{eq} for each activity it is possible to calculate the maximum number of hours (per day or per week) of "safe" exposure to each activity (i.e., number of hours of exposure for an L_{ex} of 85 dBA, assuming that for the rest of the day the teacher is not exposed to loud noise). Table II shows the duration of the different activities.

These calculated exposure times assume that the teacher is exposed to only one type of activity over a day/week. Thus,

TABLE II. L_{eq} by Activity and Type of School

	Activity				
	Singing	Percussion	Keyboard	Recorder	Band
Elementary					
No. of samples	14	9	6	5	12
Mean L_{eq}^{A}	87.1	86.9	84.4	88.2	91.7
Std d	3.8	3.4	4.0	1.9	3.3
Range	84–94	83–92	78–88	86–91	84–97
Secondary					
No. of samples	4	1			19
Mean L_{eq}^{A}	88.3	84			90.5
Std d	5.4				3.6
Range	81–94				85–98
Total					
No. of samples	18	10	6	5	31
Mean L_{eq}^{A}	87.3	86.6	84.4	88.2	90.9
Std d	4.0	3.3	4.0	1.9	3.5
Range	81–94	83–92	78–88	86–91	84–98
"Safe" exposure limits					
Hours per day	4.3	5.5	9.4	3.8	2.1
Hours per week	21.5	27.7	47.0	19.1	10.3

$^{A}L_{eq}$ measured in dBA.

these exposure times are not directly applicable to a teacher who teaches more than one type of activity per day/week.

If a teacher teaches more than one type of activity, then the daily L_{ex} can be calculated using the average time spent on each activity per day and the activity's L_{ex} from Table II. This calculation can be performed using the following equation:

$$L_{ex} = 10\text{Log}_{10}\left(\sum_i \frac{x_i}{8} 10^{\frac{L_i}{10}}\right) \quad \textbf{(1)}$$

where x_i is the average time spent on activity i (in hours), and L_i is the average L_{eq} of activity i (in dBA),

If the resulting L_{ex} is greater than 85 dBA, then the teacher is overexposed and steps should be taken to reduce the exposure, as described further in this article.

Physical Environment

Almost all the classrooms had acoustic tiles in the ceiling. Only one room had a wooden ceiling. Walls were made of concrete blocks, some partially covered with acoustical tiles. Most rooms had a large window. Also, the floor of most rooms was covered with linoleum.

With the exception of the ceilings, all surfaces were mostly reflective. Reverberation times of the classrooms were not measured. However, the subjective impression of the environments was that they were not too reverberant. This may be due to the relatively small volume of the rooms and the large number of students.

To investigate the effect of the environment on the music teacher's noise exposure, the L_{ex} of teachers teaching a similar activity to a similar size class in different rooms was examined; however, only one set of measurements of this type was made. Only one of the teachers taught two bands of 32 students in rooms of significantly different size: 19 m × 10 m × 4.5 m and 8 m × 10 m × 4 m. The noise exposures in the two classes were 96 dB and 98 dB, respectively. The doubling of the room volume appears to have lowered the noise exposure by 2 dB, which is within the measurement error. Also, the small sample size does not allow for a statistically significant conclusion.

Number of Students

The effect of the number of students on noise exposure was analyzed by comparing the L_{eq} of classes with the same activity taught by the same teacher, in the same classroom, as shown in Table III.

Doubling the number of identical, uncorrelated sound sources should increase the sound level by 3 dB. Therefore, in a band class it could be expected that doubling class size would lead to an increase in noise exposure of 3 dB. However, that doesn't appear in the results in Table III. Obviously, there are other factors that also influence the noise exposure level. Some of these factors may be the kind of music being played, whether the students were learning or performing, and the duration of the time while performing and listening to examples showed by the teacher.

TABLE III. L_{eq} in Classes with a Different Number of Students, Performing the Same Activities, and Teaching in the Same Classroom

Teacher	Students	Activity	L_{eq} (dBA)
1	22	Band	91
	22	Band	88
	31	Band	93
4	26	Band	95
	32	Band	96
	32	Band	98
5	19	Band	95
	30	Band	92
8	17	Band	88
	20	Band	86
	30	Band	89
11	18	Band	88
	30	Band	89
15	46	Recorder	87
	23	Recorder	89
	31	Recorder	91
16	25	Band	92
	27	Band	92
	22	Band	94
	21	Band	91
	60	Band	96

RECOMMENDATIONS

Engineering Noise Controls

Whenever sound levels are to be reduced, the first approach is to examine the feasibility of using engineering controls. Basically, controls consist of enclosing the source or the receiver and absorbing the acoustical energy reflected by the floor, ceiling, and walls. In the case of the music teachers, the first two controls cannot be implemented since neither the students nor the teachers can be enclosed.

The absorption of the reflected energy is most effective where the source of the sound and the receiver are relatively far away from each other. This is not the situation in a classroom where the teacher is not only close to the students, but also from time to time he or she is in the middle of the class, exposed to the direct sound from the students. Therefore, this measure is also impractical.

For those reasons, there is very little that could be done through engineering noise controls to reduce the noise levels. The only cost-effective measure that could be easily implemented is to partially cover floors with carpets wherever possible, reducing the noise from dragging chairs and the impact from walking. It would also reduce reverberation and absorb some of the ambient noise energy.

Hearing Conservation Program

Another approach to reducing the sound exposure level is to implement a hearing conservation program, which is an administrative document instituted where personnel are exposed to noise, that is, the document (1) provides guidelines for reducing the risk of hearing loss, and (2) outlines who is responsibile for different elements of the program. Some components of the program include:

- Raising awareness of the effect of excessive noise and the risk of hearing loss.
- Instituting the use of hearing protectors. The protector should be the "musician earplug" type that offers a flat frequency response (does not "color" the music) and does not excessively attenuate the sound level. Proper use, fit, and care of the plugs should be taught to all users.
- Performing audiometric tests and follow-up. The only way of knowing if the environment affects noise-exposed workers, students, etc., is by performing periodic (once every 2 years) audiometric tests, which should be of the screening type, that is, air conduction of pure-tone, as opposed to other, more complex, diagnostic tests.

CONCLUSIONS

The following conclusions can be drawn from the results in this study:

- Most music teachers are exposed to excessive sound levels during their teaching periods (L_{eq} exceeds the 85 dBA limit).
- When averaged over a whole working day, most music teachers experience an exposure that is marginally acceptable (L_{ex} close to the 85 dBA limit).

The overall conclusion from this study is that there is a potential risk of hearing loss for music teachers, and measures should be implemented for the reduction of noise exposure.

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