Sound levels and risk perceptions of music students during classes

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It is well recognized that professional musicians are at risk of hearing damage due to the exposure to high sound pressure levels during music playing. However, it is important to recognize that the musicians' exposure may start early in the course of their training as students in the classroom and at home. Studies regarding sound exposure of music students and their hearing disorders are scarce and do not take into account important influencing variables.
Therefore, this study aimed to describe sound level exposures of music students at different music styles, classes, and according to the instrument played. Further, this investigation attempted to analyze the perceptions of students in relation to exposure to loud music and consequent health risks, as well as to characterize preventive behaviors. The results showed that music students are exposed to high sound levels in the course of their academic activity.
This exposure is potentiated by practice outside the school and other external activities.
Differences were found between music style, instruments, and classes. Tinnitus, hyperacusis, diplacusis, and sound distortion were reported by the students. However, students were not entirely aware of the health risks related to exposure to high sound pressure levels. These findings reflect the importance of starting intervention in relation to noise risk reduction at an early stage, when musicians are commencing their activity as students.

Currently, it is well recognized that musicians are at risk of developing ear pathologies, particularly music-induced hearing loss (MIHL). The importance attributed to this disorder in terms of impacts for public health and society is that this term MIHL, resulting from the exposure to high loud music, is used to describe a condition similar to noiseinduced hearing loss (NIHL) (Morais et al., 2007). In fact, several studies showed that musicians are exposed to loud music in the course of orchestral ensembles (Laitinen et al., 2003; Lee et al., 2005; MacDonald et al., 2008; O'Brien et al., 2008; Jansen et al., 2009; Qian et al., 2011; Rodrigues et al., 2013, 2014), individual pratice (O'Brien et al., 2013), and teaching activities (Behar et al., 2004), among other professional and nonprofessional musical activities (Mendes & Morata, 2007). Exposure to these high sound levels was associated with hearing loss (Juman et al., 2004; Morais et al., 2007; Jansen et al., 2009; Schink et al., 2014), and other hearing-loss-related symptoms such as tinnitus, hyperacusis, and diplacusis (Morais et al., 2007; Laitinen, 2005; Laitinen et al., 2008; Jansen et al., 2009).
Because musicians are reliant upon optimal functioning of their auditory system (Kähäri et al., 2003), hearing impairment adversely affects musicians' performance, resulting in difficulties in musical perception (Royster et al., 1991). This can compromise their careers, indicating that exposure to loud music is a significant issue for such professionals.
While numerous studies regarding the sound exposure of professional musicians, particularly of orchestral musicians, are available, little is known with respect to sound exposure of music students. In fact, investigations of sound pressure levels and MIHL focused on professional musicians and on the general public listening to loud music for long periods of time (Gopal et al., 2013). However, it is important to recognize that musicians' noise exposure may start at an early stage, in the course of their training as students both in the classroom and at home. Professional musicians might begin their training at a young age, in most cases with personal classes. Subsequently, students integrate into secondary schools and higher education schools that provide

additional musical education and, consequently, are exposed to loud music in the course of individual classes and ensembles, over a broad range of hours weekly and over several years (Yoshimura et al., 2006; Miller et al., 2007; Phillips & Mace, 2008). Further, long hours of practice at home and other activities outside of the school may increase students' sound levels exposure. In fact, despite the importance of years of experience in the development of MIHL (Hoffman et al., 2006), few studies exist in that area that indicate that students are exposed to high sound levels, for a long time per week, and thus are at risk for MIHL (Henoch & Chesky, 2000; Miller et al., 2007; Phillips and Mace, 2008; Phillips et al. 2010; Gopal et al. 2013). This may exert an important impact on students' future career as musicians.
In addition, Vogel et al. (2007) indicated that this situation might influence communication and behavioral skills and, accordingly, might have important impacts on students' education, social interactions, and quality of life.
Despite previous findings with music students, these studies do not consider all the important variables that might influence students' exposure levels, particularly the effectof music style and class typology. These are two important factors that need to be considered in conjunction with instrument type (Lee et al., 2005; Hoffman et al., 2006; O'Brien et al., 2008, 2013). Considering all the relevant aspects, this study aimed to examine sound pressure level exposure of music students with different music styles, classes, and according to the instrument played. Further, this study attempted to assess the perceptions of students in relation to adverse health risks due to exposure to loud music, as well as to characterize preventive behaviors.

METHODS

Study Participants

The study was developed at two different levels of education schools (a secondary school and a higher education school). Measurements of the noise level were performed independently in each school and involved two groups of jazz (one of each school) and another group of classical music (secondary school), for a total of 12 students of jazz and 12 students of classical music, selected based on their own instrument and their place in the ensemble classes.
Questionnaires for the analysis of students' views and behavior in relation to loud music were applied in both schools. Included in the study were 240 students: 51.2% from the secondary school and aged 11–20 yr (mean: 15.3 yr; SD: 1.9); 48.8% higher education school and aged 17–37 yr (mean: 20.6 yr; SD: 3.3). A further description of the students by scholar year is presented in Table 1.

TABLE 1. Students' Characterization

School	Scholar year	Age (x ± SD)	Gender (%)
Secondary school	7	11.8 (±0.4)	M = 35.3 F = 64.7,
	8	13.8 (±0.4)	M = 53.8, F = 46.3
	10	15.2 (±0.6)	M = 62.5, F = 37.5
	11	16.3 (±0.9)	M = 59.0, F = 41.0
	12	17.3 (±0.8)	M = 59.1, F = 40.9
Higher education school	1	19.3 (±3.0)	M = 51.6, F = 48.4
	2	22.4 (±5.0)	M = 50.0, F = 50.0
	3	22.1 (±2.6)	M = 70.2, F = 29.8

Classroom Noise Measurements

At the initial stage, the aim of the study and various procedures to be adopted were explained to all students selected and then any additional questions were clarified. As the sample was defined based on ensemble classes and instrument, students of different classes were included (orchestral classes are composed by students from different years or courses). Consequently, each student was asked to deliver the weekly schedule to the responsible researcher, as well as his or her e-mail and mobile contact. Based on this information, a work plan was established to assess the students' sound level exposure.

Sound pressure levels were measured according to the ISO 9612:2009 and the Decree-Law n◦ 182/2006 (Portuguese legislation). Three Quest NoisePro and seven CESVA DC112 personal noise dosimeters were used to collect data of equivalent continuous sound pressure levels ($L_{p,A,eqT}$) and peak sound pressure levels ($L_{p,Cpeak}$) (each dosimeter was verified before and after each series of measurements for 94 dB(A) at 1000 Hz with a sound calibrator).

Before the class, each student was equipped with a dosimeter. After the subjects assumed their position in the classroom, the dosimeter microphone was connected to the test subject's shirt by investigators at a height of 4 cm above the shoulder closest to the most exposed ear. For string instruments, the microphone was placed on the right side. The assessment was conducted in a discreet way in order to not interfere with normal behavior and movements of the students in the course of the class/performance. Students were instructed to behave typically in the classroom and to be careful with the equipment, especially not to touch the microphone, remove it on their own, or speak directly into it. If one of these situations occurred, the students reported the situation to the responsible researcher.

Students wore noise dosimeters throughout the entire class. All classes directly related to music teaching were evaluated with an acoustic dosimeter for a 2-wk period. The classes were grouped as classes with instrument (individual classes and ensemble) and practical–theoretical classes (classes without instruments, but with the production of musical sounds).

Students' Risk Perception Analysis

Students' perceptions about sound exposure, its effects on health and performance, and protective behaviors were analyzed using a questionnaire. The construction of this questionnaire was similar to the one proposed by Laitinen (2005) for symphony orchestras. Two different questionnaires were constructed and tested, taking into account differences between schools with respect to classes procedures and organization. Before the application of the questionnaire, a validation procedure was performed (by seven students and two teachers) taking into account the clarity of meaning of the questions and linguistic terms, as well as applicability of questions and scales used. Some improvements related to the language used and scales were suggested and considered in the final version.

The questionnaire was divided into five parts. The first part refers to students' characterization, such as age, gender, course, and year in school. In the second part, questions regarding weekly exposure were included: instrument played, hours of practice in different types of classes, hours of individual and group study, and exposure to other loud sound sources, such as use of headphones, listening to concerts, and playing in garage bands. An open option for other activities was also considered. The third part of the questionnaire analyzed the perception of students regarding the sound levels with respect to (1) different types of classes, (2) individual and group study, and (3) different instruments (5-point Likert scale: 1 =very low; 5 = very high). The implications of the sound levels on the students' performance were also analyzed in this group (5-point Likert scale: 1 = not affect; 5 = greatly affect). The fourth part was composed of seven questions aimed at gathering students' views on health effects, such as (1) general negative health effects (5-point Likert scale: 1 = not affect; 5 = greatly affect); (2) degree of care about health effects (a list of heath effects was presented and assessed on a 5-point Likert scale: 1 = none concern; 5 = very high concern); (3) previous hearing exams; and (4) ear symptoms (tinnitus, hyperacusis, diplacusis, sound distortion). In the last and fifth part of the questionnaire, students were asked about measures for sound level reduction, particularly regarding usage of hearing protection in different situations (5-point Likert scale: 1 = never; 5 = always). If students indicated use of hearing protection, they were queried about type used, and if not, the basis for non use.

Students were also asked about the use of instrument mutes (5-point Likert scale: 1 = never; 5 = always). At the end, they were enquired about additional care to reduce sound levels in their own practice. An open-ended question was also included in the final part of the questionnaire for comments. Students completed the questionnaires as part of a theoretical class, and were notified that their participation was voluntary and confidential and that results would only be used for purposes of this research.

Data Treatment

Data of measurements were transferred to the Capture Studio Editor Software (CESVA Instruments, S.L.U., Barcelona, Spain) and QuestSuite Professional Software (Quest Technologies, Oconomowoc, WI) for processing. Values of $L_{p,\mathrm{A,eqT}}$ and $L_{p,\mathrm{Cpeak}}$ were collected and used to characterize students' sound level exposure in the course of different classes. All statistical analyses were conducted using statistical software package IBM SPSS Statistics version 20. To investigate the influence of age and the use of hearing protection with respect to the health effects, as well as the relationship between the use of hearing protection and self-reported health effects, the Pearson chi-squared test was utilized.

Differences in the sound pressure levels between schools, classes, instruments, and music styles were tested with Mann–Whitney and Kruskal–Wallis tests. The Mann–Whitney test was also used to determine differences between both schools in relation to hours of practice, sound level perception, and influence of high sound levels on students' performance and health. The significance level used was $p < .05$.

TABLE 2. Summarized Data for $L_{p,\mathrm{A,eq}T}$ and $L_{p,\mathrm{Cpeak}}$ by Instrument in Jazz students of Secondary School

	Individual classes				Ensemble classes			
	$L_{p,\mathrm{A,eq}T}$ dB(A)		$L_{p,\mathrm{Cpeak}}$ dB(C)		$L_{p,\mathrm{A,eq}T}$ dB(A)		$L_{p,\mathrm{Cpeak}}$ dB(C)	
Instrument	Average	Range	Average	Range	Average	Range	Average	Range
Doublebass	76.7	74.3–79.0	110.5	108.2–112.7	88.9	83.8–93.9	125.1	123.3–126.8
Guitar	77.7	76.1–79.2	115.1	112.1–118.0	94.5	92.1–96.9	124.5	123.4–125.6
Saxophone	88.0	86.4–89.5	127.2	124.5–129.9	99.0	98.8–99.1	135.2	133.9–136.5
Trombone	92.8	90.2–95.4	126.1	120.2–132.0	100.9	100.2–101.6	131.65	131.0–132.3
Percussion	94.5	93.2–95.7	137.3	136.2–138.4	98.8	98.4–99.2	141.4	140.4–142.3
Piano	84.3	82.4–85.9	117.2	114.1–120.3	—	—	—	—

Note. —, Not determined. There is no significant effect of instrument type in $L_{p,\mathrm{A,eq}T}$ values [$\chi^2(6) = 9.048$, $p > .05$]; there are significant differences between individual and ensemble classes [$U = 6.000$, $Z = -3.450$, $p < .001$].

TABLE 3. Summarized Data for $L_{p,\mathrm{A,eq}T}$ and $L_{p,\mathrm{Cpeak}}$ by Instrument in Jazz Students of the Higher Education School

	Individual classes				Ensemble classes			
	$L_{p,\mathrm{A,eq}T}$ dB(A)		$L_{p,\mathrm{Cpeak}}$ dB(C)		$L_{p,\mathrm{A,eq}T}$ dB(A)		$L_{p,\mathrm{Cpeak}}$ dB(C)	
Instrument	Average	Range	Average	Range	Average	Range	Average	Range
Doublebass	75.1	72.3–77.8	106.2	105.2–107.1	86.9	82.2–92.1	122.8	116.8–127.4
Guitar	75.0	73.1–76.9	106.1	103.3–108.9	86.8	85.4–89.0	122.5	119.1–125.9
Trombone	—	—	—	—	92.5	88.4–94.8	127.6	124.0–131.6
Percussion	85.2	66.6–95.0	129.9	111.5–147.3	89.4	86.8–96.4	129.9	124.5–137.2
Vibraphone	95.3	—	119.7	—	89.6	87.9–92.7	123.7	119.7–127.5
Piano	—	—	—	—	86.9	84.4–91.5	122.8	115.3–127.7

Note. —, Not determined. There is a significant effect of instrument type in $L_{p,\mathrm{A,eq}T}$ values [$\chi^2(5) = 11.474$, $p < .05$]; No significant differences exist between individual and ensemble classes [$U = 122.000$, $Z = -1.735$, $p > .05$].

RESULTS

Sound Level Exposure

Regarding jazz students, Tables 2 and 3 summarize the results for the classes with instrument practice for both schools, secondary school and higher education school, respectively.

Classes were grouped in individual classes and ensemble. The results of both schools showed that there was an effect of instrument type in the level of sound exposure, despite significant differences only being found for the higher education school. For the two schools, sound exposure levels ranges in individual classes were 72.3–79 dB(A) for doublebass, 73.1–79.2 dB(A) for guitar, 86.4–89.5 dB(A) for saxophone, 90.2–95.4 dB(A) for trombone, 66.6–95.7 dB(A) for percussion, and 82.4–85.9 dB(A) for piano.

For vibraphone only one individual class was possible to assess, achieving an $L_{p,\mathrm{A,eqT}}$ of 95.3 dB(A). In general, higher values of $L_{p,\mathrm{A,eqT}}$ were found for percussion, vibraphone, saxophone, and trombone, and lower for doublebass, guitar, and piano. Significant differences were found in the distributions between individual classes and ensembles when analyzing the data from the two schools together. At ensemble classes, in both groups, the values of $L_{p,\mathrm{A,eqT}}$ were higher for all instruments, except for the vibraphone, with ranges of 82.2–93.9 dB(A) for doublebass, 85.4–96.9dB(A) for guitar, 98.8–99.1 dB(A) for saxophone, 88.4–101.6 dB(A) for trombone, 87.9–92.7 dB(A) for vibraphone, 86.8–99.2 dB(A) for percussion, and exposure levels refers to the doublebass, piano, and guitar, with the level of sound exposure markedly higher at the ensemble classes.

Another interesting result refers to the difference in noise level at both schools, particularly at the ensemble classes. Higher levels of noise exposure were found at the secondary school. At this school, the ensemble classes assessed were only the orchestral classes with a higher number of students playing in the room. In the higher education school, ensemble classes included orchestral, combo, and improvisation, each one with a different number of students playing, but, in general, always with a lower number than in ensembles classes of the secondary school.

It is to be noted that not all students were assessed at both individual and ensemble classes. In the secondary school it was not possible to assess the piano at group classes, since the piano student did not play in the assessed classes. In the higher education school, individual classes of trombone and contrabass werenot assessed, because the relevant student or teacher did not attend the classes. In relation to the vibraphone, it was only possible to assess one individual class. Tables 2 and 3 also show higher levels of $L_{p,\mathrm{Cpeak}}$ for percussion at individual classes and saxophone, as well as for percussion at ensembles.

Despite the absence of specific guidelines for music students' exposure sound levels, Portuguese legislation for professionals may beused as a comparative guideline (Decree-Law n◦ 182/2006). Therefore, the saxophone was found to exceed the lower legal action level (135 dB(C)) and percussion surpassed the value of the exposure limit (140 dB (C)) at both Schools.

TABLE 4. Summarized Data for $L_{p,A,eqT}$ and $L_{p,Cpeak}$ by Instrument in Classical Music Students

	Individual classes				Ensemble classes			
	$L_{p,A,eqT}$ dB(A)		$L_{p,Cpeak}$ dB(C)		$L_{p,A,eqT}$ dB(A)		$L_{p,Cpeak}$ dB(C)	
Instrument	Average	Range	Average	Range	Average	Range	Average	Range
Violin	85.1	82.0–88.2	118.3	113.8–122.7	81.6	76.3–85.0	112.1	105.8–117.3
Viola	80.9	74.3–87.4	115.4	111.1–119.7	78.5	76.6–80.3	114.5	110.4–118.6
Cello	84.8	83.6–85.9	111.8	108.9–114.6	78.0	75.8–80.1	113.1	109.4–117.9
Doublebass	74.7	73.9–75.4	107.2	105.1–109.2	75.7	74.3–77.0	111.1	106.1–116.1
Clarinet	77.1	86.1–88.0	116.1	114.8–117.3	82.1	80.7–83.4	120.8	112.6–129.0
French horn	92.0	—	114.7	—	93.0	—	119.4	—
Percussion	90.8	86.3–93.4	137.0	131.8–142.4	91.92	86.5–96.5	135.7	132.7–140.4

Note. —, Not determined. There is a significant effect of instrument type in $L_{p,A,eqT}$ values [$\chi^2(7) = 32.608$, $p < .001$]; there are significant differences between individual and ensemble classes [$U = 166.000$, $Z = -2.019$, $p < .05$]. There are significant differences in $L_{p,A,eqT}$ values between both music styles (classical music and jazz) at ensembles [$U = 10.000$, $Z = -4.275$, $p < .001$].

Table 4 presents the results for the classes with instrument practice for classical music students of the secondary school. A significant effect of instrument type in the level of sound exposure was found. At individual classes, sound exposure levels ranges were 82.0–88.2 dB(A) for violin, 74.3–87.4 dB(A) for viola, 83.6–85.9 dB(A) for cello, 73.9–75.4 dB(A) for doublebass, 86.1–88 dB(A) for clarinet, and 86.3–93.4 dB(A) for percussion. For the French horn only one individual class was possible to assess with $L_{p,\mathrm{A,eqT}}$ of 92.0 dB(A). At ensemble classes, the values of $L_{p,\mathrm{A,eqT}}$ had ranges of 76.3–85 dB(A) for violin, 76.6–80.3 dB(A) for viola, 75.8–80.1 dB(A) for cello, 74.3–77 dB(A) for doublebass, 80.7–83.4 dB(A) for clarinet, and 86.5–96.4 dB(A) for percussion. The French horn achieved an $L_{p,\mathrm{A,eqT}}$ of 92 dB(A). Significant differences were also found between individual and ensemble classes in the classical music students' sound exposure levels. However, in this case, higher levels were noted for individual classes. With respect to $L_{p,\mathrm{Cpeak}}$

values, higher levels of exposure were observed for percussion at both individual and ensemble classes, exceeding the value of the 140 dB (C), the Portuguese legal exposure limit.
Differences in $L_{p,\text{A,eqT}}$ values between both music styles were analyzed. Data showed that in individual classes there were no marked differences in the distributions of both jazz and classical music; however, at ensembles, these differences were significant with $L_{p,\text{A,eqT}}$ values higher in jazz ensemble classes. However, it is important to note the small number of brass and woodwinds instruments included for the classical musicians group. Other types of classes were also assessed. For the higher education school the number of classes directly linked to music was higher than in the secondary school. Average $L_{p,\text{A,eqT}}$ was 76.8 ± 3 dB(A) in rhythmic fundamentals, 78.6 ± 2.9 dB(A) in auditory training, 74.7 ± 2.6 dB(A) in jazz composition, 70.4 ± 3.9 dB(A) in small arrangements, and 71.2 ± 2.3 dB(A) in story of jazz. For the secondary school the $L_{p,\text{A,eqT}}$ values were 75.9 ± 4 dB(A) for music theory, 81.6 ± 2.2 dB(A) for choral music, and 76.0 ± 2.7 dB(A) for analysis and composition techniques.

TABLE 5. Hours of Exposure for Both Working Hours and Other Activities (h/wk)

		Secondary school	Higher education school	Differences between schools
Working hours in school activities	Individual classes	2.2 ± 0.9	1.42 ± 1.1	$U = 2784.000$, $Z = -8.495$**
	Ensemble classes	2.4 ± 1.8	4.26 ± 2.6	$U = 6001.000$, $Z = -7.825$*
	Other group classes	2.7 ± 1.4	1.79 ± 3.7	$U = 3060.000$, $Z = -7.825$**
	Individual study	11.4 ± 7.1	18.95 ± 8.9	$U = 3120.500$, $Z = -7.592$**
	Group study	1.2 ± 1.5	2.68 ± 3.4	$U = 4435.500$, $Z = -5.248$**
Hours in other activities	Garage bands	1.6 ± 1.8	1.5 ± 1.8	$U = 7022.000$, $Z = -0.344$
	Concerts	0.4 ± 0.8	1.0 ± 1.3	$U = 5305.500$, $Z = -3.877$**
	Headphones	4.0 ± 6.1	5.5 ± 7.8	$U = 6530.000$, $Z = -1.265$
	Other	0.2 ± 0.7	1.8 ± 2.9	$U = 7170.500$, $Z = -0.105$

Note. Significance: *$p < .05$; **$p < .001$.

Students' Perception About Sound Exposure

From Table 5 it is possible to note that students predominantly spend a large number of hours per week practicing. Emphasis needs to be given to the individual study where time spent practicing is high in both schools (secondary school: 11.4 ± 7.1; higher education school: 18.95 ± 8.9). Despite the large number of practice hours in both schools, there were significant differences in their distributions in relation to working hours (individual classes; ensembles; other group classes; individual study; and group study). In general, more hours of practice were found for higher education school students in ensemble classes, individual study, and group study. In addition, students spent a long time being exposed to high sound levels from other sources, as is the case for playing in garage bands, listening to live concerts, and music with headphones. In general, higher education school students spent more time on these activities; however, marked differences in distributions were only found for concerts.

TABLE 6. Perception About the Level of Sound by Class and Instrument (%)

		Secondary school					Higher education school				
		VL	L	M	H	VH	VL	L	M	H	VH
Classes	Individual	1.6	12.3	69.7	13.1	3.3	0.9	23.9	68.4	6.8	0.0
	Ensemble	0.9	3.5	43.5	40.9	11.3	1.2	0.0	11.1	50.6	37.0
	Other group classes	3.4	22.9	62.7	10.2	0.8	2.7	17.8	60.3	17.8	1.4
	Individual study	1.6	20.5	62.3	13.1	2.5	3.5	33.0	50.4	13.0	0.0
	Group study	7.1	6.1	43.4	37.4	6.1	0.0	15.7	54.9	28.4	1.0
	Strings	2.4	32.5	50.4	13.8	0.8	0.9	40.2	47.0	12.0	0.0
Instrument	Woodwinds	0.8	7.4	51.6	38.5	1.6	0.0	5.1	54.7	39.3	0.9
	Brass	0.0	0.8	8.2	56.6	34.4	0.0	0.0	2.6	48.7	48.7
	Percussion/timpany	0.8	0.0	13.0	53.7	32.5	0.0	0.0	4.3	59.0	36.8
	Piano	1.6	13.0	57.7	26.0	1.6	2.6	14.5	53.8	28.2	0.9

Note. VL, "very low"; L, "low"; M, "moderate"; H, "high"; VH, "very high." Differences in the distributions between both schools were found in relation to sound level perception for individual classes [$U = 6024.000$, $Z = -2.666$, $p < .05$], other group classes [$U = 5259.000$, $Z = -3.869$, $p < .05$], and individual study [$U = 6106.000$, $Z = -2.258$, $p < .05$]. Significant differences between schools were found for brass [$U = 5905.500$, $Z = -2.708$, $p < .05$].

The students were asked to assess the sound level of different classes and instrument groups. The distributions of students perceptions are presented in Table 6. In general, ensembles are considered the noisiest classes. Differences in the distributions between both schools were found in relation to sound level perception for individual classes, other group classes, and individualstudy. Students in the secondary school perceived higher sound levels in individual classes and individual study, and higher levels were observed by higher education school students for other group classes. In relation to instrument groups, higher sound levels were perceived for brass and percussion (timpany). Significant differences between schools were found for brass, as this group of instruments was perceived as noisiest by higher education school students.

Health Effects, Prevention, and Protection

Students were questioned in relation to the influence of exposure to high sound levels in their performance. Most of the students believed that this exposure affected their performance to some extent (secondary school = 44.1%; higher education school = 23.1%) or with a greater degree (secondary school = 38.1%; higher education school = 48.7%). Only a few students identified a significant influence of loud music in his/her performance (secondary school = 2.5%; higher education school = 12.%). In general, students from the higher education school are the ones that felt greater influence. Students were also asked regarding the negative health effects attributed to exposure to high sound pressure levels. Perception of greater effects was found by higher education school students.

However, a substantial number of respondents of both schools did not identify any adverse effects (secondary school = 17.2%; higher education school = 7%) or identified a minimal effect on health (secondary school = 32%; higher education school = 25.2%).

TABLE 7. Degree of Concern With Health Effects (%)

	Secondary school					Higher education school				
	N	L	CD	H	VH	N	L	CD	H	VH
Stress	21.5	21.5	33.1	17.4	6.6	12.9	20.7	37.1	24.1	5.2
Headache	13.2	20.7	35.5	21.5	9.1	6.8	15.4	33.3	35.0	9.4
Heart rate	29.2	28.3	25.8	12.5	4.2	19.5	29.2	29.2	17.7	4.4
Hearing loss	36.4	20.7	17.4	10.7	14.9	17.2	15.5	23.3	23.3	20.7
Tinnitus	21.0	27.7	26.9	20.2	4.2	11.6	23.2	27.7	25.0	12.5
Hyperacusis	37.1	22.4	21.6	15.5	3.4	25.5	20.8	26.4	15.1	12.3
Diplacusis	44.4	21.4	19.7	9.4	5.1	37.1	22.9	18.1	14.3	7.6
Sound distortion	41.4	25.9	21.6	5.2	6.0	26.6	23.9	25.7	15.6	8.3

Note. N, "none"; L, "low"; CD, "to a certain degree"; H, "high"; VH, "very high." Significant differences were found in the distributions of both schools for hearing loss [$U = 5261.000$, $Z = -3.678$, $p < .001$]. A dependence of the level of concern on the students' age was identified [$\chi^2(15) = 26.253$, $p < .05$].

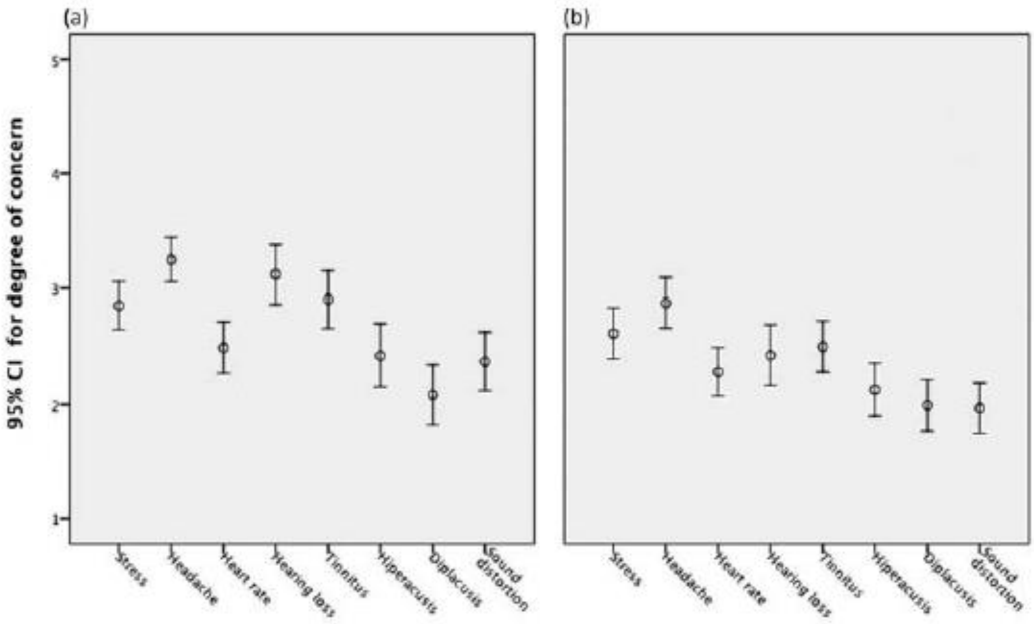

FIGURE 1. Degree of concern with health effects: a) Higher Educational School b) Secondary School.

Table 7 and Figure 1 present the degree of concern with different health effects. In general, students indicated low concerns in relation to health effects. Higher levels of concerns were identified for headache, hearing loss, and tinnitus. Data also show a higher degree of concern for higher education school students. However, significant differences were only found in the distributions of both schools for hearing loss. These results suggest dependence of the level of concern on the students' age, increasing with age. It is also important to note that a substantial number of students presented no concerns in relation to different health effects, particularly in regards to hearing loss (secondary school = 36.4%; higher education school = 17.2%), hyperacusis (secondary school = 37.1%; higher education school = 25.5%), diplacusis (secondary school = 44.4%; higher education school = 37.1%), and sound distortion (secondary school = 41.4%; higher education school = 26.6%).

TABLE 8. Reported Hearing Disorders (%)

	Secondary school	Higher education school
Tinnitus	69.9	67.5
Hyperacusis	30.1	31.6
Diplacusis	30.1	8.5
Sound distortion	14.6	29.1

The self-reported hearing disorders are summarized in Table 8. Tinnitus was the highest reported disorder between both schools (secondary school = 69.9%; higher education school = 67.5%) and its incidence was higher after ensembles (secondary school: sometimes 29.1%; frequently 5.8%; always 2%; higher education school: sometimes 22.8%; frequently 5.1%; always 3.8%). Hyperacusis was the second most reported disorder (secondary school = 30.1%; higher education school = 31.6%). In secondary school a high number of students also reported diplacusis (30.1%) and in higher education school sound distortion (29.1%).

Students were also queried in the questionnaire about audiologic evaluations. The results showed that in the secondary school 43.6% of the students reported having performed an audiologic evaluation and in the higher education school 40.7%.

In relation to hearing protection, a few students reported its use, but in most of the situations on an occasional basis (rarely or sometimes). In the secondary school 4% used hearing protection in individual classes, 10.6% in ensembles, 7.3% in individual training, and 8.1% at group training. When utilizing hearing protection, 56.3% choose ear plugs, 12.5% ear muffs, 25% specific protection for musicians, and 6.2% other hearing protections. When they opted to not use it, most respondents indicated that they never try to use them (52.8%) and they think that they are not necessary (36.6%).

In the higher education school there was 5.2% hearing protection use in individual classes, 12.8% in ensembles, 7.8% in individual training, 7.7% at group training, and 13.8% when playing in garage bands. When wearing hearing protection, 74.3% choose ear plugs, 3.2% ear muffs, 19.4% specific protection for musicians, and 3.1% molded ear plugs. However, when not used, a large number of students indicated that they never try to use them (47.9.8%) and a significant number reported an effect of hearing protection on their performance (23.1%), in sound quality (25.6%) and ability to listen their own instrument (27.4%), as the key problems that inhibit them from using hearing protectors. It is important to note that some of the students also indicated that they sometimes used cotton wool, regardless of the use of other protection type. No correlation was found between the use of hearing protection and health effects' concerns or self-reported.

Mutes are the protection most used, even if students have not used them always (51.2% in the secondary school; 65% in the higher education school). Other protective behaviors were also indicated by few students (8.1% in the secondary school; 12% in the higher education school), including (1) reduction of sound level of the instrument/amplifier, (2) decrease time of exposure, (3) reducing the sound level of television and other equipment, and (4) changing his or her position in relation to the amplifiers, when referring to amplified music.

DISCUSSION

Sound Level Exposure

The results of this study showed that sound pressure levels during classes with instrument practice are significantly high in both music styles, exposing students to harmful noise levels during daily practice. These findings are in agreement with previous studies in school settings (Phillips and Mace, 2008). Further, the sound pressure levels found in this study are comparable to the sound levels observed for professional musicians for rehearsals and performances (Laitinen et al., 2003; Lee et al., 2005; MacDonald et al., 2008; O'Brien et al., 2008; Rodrigues et al., 2013; 2014). Other important factors for exposure include dependence on level of exposure of the instrument played, type of class, and music style. These findings are similar to those of O'Brien et al. (2013), who also noted that sound exposure is dependent upon instrument played, dynamic level at which the instrument is played, and practice activity chosen.

Higher sound levels were found for brass and percussion students of both music styles.

These students were also exposed to dangerous $L_{p,\text{Cpeak}}$ values, with the limit value of 140 dB(C) according to the Decree-Law n◦ 182/2006 (Portuguese legislation) in some cases exceeded. These results are in agreement with other studies with both students and professional musicians (O'Brien et al., 2008; Phillips & Mace, 2008).

Differences between individual classes and ensembles were also noted, but the results differed according to music style. Higher values were found in individual classes for classical music students that played string instruments.

These higher levels may be due to smaller class size and acoustic features of practice rooms (O'Brien et al., 2008) and to lack of a need to blend or match tone quality with another musician (Laitenain et al., 2003). However, for jazz students, exposure levels tended to be higher in ensembles, particularly for less noisy instruments such as doublebass, guitar, and piano. These results may be attributed to contribution of other instruments to enhance level of sound exposure, as well as to use of amplifiers and their position in relation to it.

In general, higher sound levels were found for jazz students in the ensemble compared to classical music students. The jazz orchestral music dynamics may be an important contributor to these findings. A typical jazz orchestra is associated with musical arrangements that often call for extended pitch and dynamic levels, especially in the high registers (Henoch & Chesk, 2000). The use of amplifiers might also account for these results. Amplifiers intensify the sound pressure levels. In addition, teachers sometimes encourage students to play high, thus increasing sound exposure levels. These features, combined with prolonged exposure time, enhance the risk of hearing damage (Hoffman et al., 2006; Morais et al., 2007; Schmidt et al., 2011). However, it is important to note that the differences detected between both music styles might be lower than the actual observed values. In this study, a small number of brass and woodwinds instruments were considered for the classical music group, that is, French horn and clarinet, when other loud instruments, such as trumpet and trombone, among others, are also the source of high sound levels. If other noisy instruments were included, differences for these groups might be smaller.

Differences in the exposure levels were also found between jazz music students of both schools. In general, exposure levels were higher in the secondary school. These findings may be due to differences in the practice room (size and acoustical conditions) and number of students playing in the ensembles, which was significantly higher in the secondary school, similar to to differences in repertories and dynamics (O'Brien et al., 2008; Rodrigues et al., 2014).

It is interesting to note that in general, values achieved in this study for individual classes are lower than those found in studies with professional musicians for individual practice (O'Brien et al., 2013). However, features of the venue and dynamics of the class might explain these data. Students in individual classes are not always playing and need to exchange ideas with the teacher. This situation is clear in the observations found for the percussion student of the higher education school, where the minimal value of $L_{p,\text{A,eqT}}$ attained for individual classes was 66.6 dB(A). On this day, the individual class did not involve as much practice as usual, since theoretical issues were analyzed.

However, in other cases, student and teacher played together, side by side, and the values of $L_{p,\text{A,eqT}}$ achieved reached 95 dB(A).

In theoretical–practical classes, where piano or recorded music is played, or students sing or clap hands to mark rhythm, loud sounds are produced several times, and this might also be an important contributing component for overall students' exposure levels that should not be overlooked. In fact, this study showed that sound pressure levels produced in these type of classes are also important, in some cases close to or exceeding 80 dB(A).

Students' Perception About Sound Exposure

Data suggests, in general, that respondents displayed a low perception regarding the sound levels in the course of different classes and training. Higher sound levels were perceived for ensembles

and moderate sound levels for individual classes and individual study. However, several students also classified the sound levels during different classes as low.
Further, the study showed that the sound level in the course of individual classes is also high.
Even in individual training the sound level may be high, since previous studies demonstrated that sound levels during individual practice are, in some cases, higher than in ensembles (O'Brien et al., 2013).
With respect to type of instrument, students considered brass and percussion as the noisier instrument types. Moreover, the strings were perceived as those that provide lower sound pressure levels. This is in accordance with the sound pressure levels identified in the course of different classes, particularly in individual classes, and is in agreement with O'Brien et al. (2013) and Rodrigues et al. (2014). It is important to note that a considerable percentage of students indicated string instruments as producing low sound levels. However, despite the lower the sound level produced by these instruments in comparison with other instruments types, the sound levels are still significant.
The risk of MIHL was found to be greater in higher education school students, since the amount of hours spent practicing is higher. However, the number of hours spent for practice was found to be high in both schools.
In fact, music students are subjected to an intensive training program to prepare them for a professional career in music (Phillips and Mace, 2008), involving them in multiple ensembles and individual practice, as well as other classes typically linked to production of high sound pressure levels. This situation is worsened when individual and group study outside of the schools is included. Data showed that students spend a long time practicing alone at home. Further, they also study with other colleagues and the sound pressure level produced at this practice might be considerably high. This increases the number of hours of practice per week by students. In fact, students need to train several hours to improve their skills, and if motivated spend even more time practicing. Previous studies also demonstrated that the number of hours that students practice is high, when considering the sound levels to which they are exposed. Phillips and Mace (2008) noted that the number of hours of practice per day between higher education school students was an average of 2.3 h. Miller et al. (2007) found most students practicing more than 10 h/wk, and Yoshimura et al. (2006), in a study of higher education school piano students, reported an average of 20 h/wk of individual practice, with some students reporting more than 40 h/wk. In our study the time spent in practice was higher than 20 h/wk for several students. Further, some higher education school students played in other bands, outside school, and in some cases nosier music styles such as heavy metal, and in rooms with poor acoustic conditions (Almeida et al., 2014). All participating students in our study also reported other risky practices, such as listening to music using headphones or attending concerts. This type of exposure without recognizing the risk of permanent hearing loss might increase severely the risk of MIHL.

Health Effects, Prevention, and Protection

The sound levels that students are exposed to in the course of their academic activity, as music students, suggest that they are at risk of hearing damage in the same way as professional musicians. Gopal et al. (2013), in an experimental study, found that students exposed to loud music exhibit higher temporary threshold shifts (TTS) after practice classes compared to students less exposed. This temporary loss usually disappears with hearing rest. However, with a cumulative exposure to high sound levels, permanent hearing loss may occur. Further, Gopal et al. (2013) found an incidence of tinnitus in the experimental group higher than in the control group (64% of the subjects reported tinnitus). Miller et al. (2007) observed a higher prevalence of tinnitus among music students, where 63% of students reported tinnitus after exposure to loud music. In our study a high prevalence of tinnitus was detected, particularly after ensembles, with a prevalence of 69.9% in the secondary school and 67.5% in the higher education school.
In fact, the results of the two schools are similar and in agreement with previous findings. Further, a significant prevalence of hyperacusis was also found in both schools, diplacusis in the secondary school, and sound distortion in the higher education school. Once hearing lossrelated symptoms were noted, data suggested that students, throughout their exposure time, might develop MIHL.

In fact, Phillips et al. (2010), in a study with higher education school students (aged 18–32 years), found a prevalence of 45% of MIHL in at least one ear. These observations are in agreement with professional musicians studies, suggesting that MIHL occurs at an early stage (Jansen et al., 2009; Phillips et al., 2010). This hearing damage may have consequences on musicians' performance (Royster et al., 1991).

Despite these worrisome results, this study also showed that students do not appear concerned with this issue. In fact, a considerable number of students did not appear to be worried about MIHL or about the influence of exposure to high sound levels on their performance. The concerns with other hearing effects, such as tinnitus, hyperacusis, and diplacusis, were also low. However, data also demonstrated that these concerns tend to increase with age, and may be due to enhanced knowledge of these students regarding these issues.

Data indicated that students are resistant to the use of hearing protection. Only a few students reported using it, and in most cases not frequently. Most of the respondents never tried to use it or believed that this kind of protection is not needed. In the higher education school, students are more likely to not use hearing protection due to the influence on their performance or in the quality/level of the sound perceived. The low perception of the sound levels and health effects by students might also be responsible for these findings. Widén and Erlandsson (2007) noted that if individuals identify themselves as vulnerable to negative consequences of loud music, they are more willing to adopt a preventive behaviour; otherwise, risky behaviors are adopted. These results differ from the findings of studies with professional musicians (Laitinen and Poulsen, 2008; O'Brien et al., 2013). O'Brien et al. (2013) found that 40% of musicians use earplugs during practice, despite 71% using this protection occasionally or sometimes. Miller et al. (2007) in a study with music students observed a higher percentage of students using hearing protection while playing their instruments.

Differences in the type of the hearing protection used were found between students and professional musicians. Students tended to use common ear plugs. In contrast, professional musicians utilized "musician" earplugs (O'Brien et al., 2013). This may be attributed to the price of the hearing protection, as students have fewer financial resources and opt for the use of cheaper protection. The use of mutes is the most common protection used among the students. It is also interesting to note that some of students adopted other preventive behaviors such as reduction of sound levels (e.g., in the amplifiers) and time of exposure.

It is important to note that this study focused on exposure of students to loud music and effects on the hearing system. However, auditory system injury may also result from exposure to a wide variety of drug and chemicals with ototoxicity properties (Toppila et al, 2001; Fechter, 2004; Fuente and McPherson, 2006; Guthrie et al., 2014). It is important to make all students and professional musicians aware of this, in order to protect their hearing acuity, which is their working tool.

CONCLUSIONS

The findings of this study showed that music students are exposed to high sound levels in the course of their academic activity.

This exposure is potentiated by practice outside of school and other activities such as playing in bands, listening to music with headphones, and attending to concerts. In view of this, students are at risk of developing MIHL in the same way as professional musicians.

This reflects the importance of starting intervention in relation to noise risk reduction early, when musicians are starting their activity as students.

The study also demonstrated that, despite the risk that students are facing due to the exposure to loud music, they are not entirely aware of this problem. Accordingly, schools need to provide additional programs on this issue in order to ensure that all music students receive the necessary education and become aware of the risks related to loud music exposure.

Schools are in a privileged position to facilitate change and promote among students preventive behaviors that also apply as professionals.

In fact, schools are responsible both to inform all students about the risks associated with music activities and to apply strategies to prevent or minimize the risk of hearing loss on behalf of students. Schools need to establish and implement a hearing conservation program.

Students can also apply some strategies to diminish their risk of MIHL, such as reducing duration of the exposure, looking for calm places to rest or study, resting between exposures, participating in annual audiologic evaluations, using proper hearing protection, and decreasing levels of the exposure by using mutes, screens, and other measures applied according the instrument.
This study was limited by the lack of some noise level evaluations, particularly at individual classes in the higher education school group of students. However, it is believed that this limitation was not critical for this study, since a general perspective of different students' exposure levels at these settings was provided.
Future investigations need to aim for further analysis of the influence of the exposure to loud music on hearing acuity by performin audiological exams. Other interest groups of students, as well as teachers, need to be analyzed in order to provide further information to include in a hearing conservation program.
Issues related to exposure to drugs and chemicals with ototoxicity properties also need to be considered.

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