



International Journal of Occupational and Environmental Safety

University music teachers' exposure to noise and hearing loss

A. Delgado^a, F. Carvalho^b, R. B. Melo^c

^aLaboratório de Ergonomia, Universidade de Lisboa, Lisboa, PT (delgado.ana3@gmail.com) ORCID: 0000-0002-6240-3150. ^bLaboratório de Ergonomia, CIAUD, Universidade de Lisboa, Lisboa, PT (fcarvalho@fmh.ulisboa.pt) ORCID: 0000-0001-5688-2899. ^cCIAUD, Universidade de Lisboa, Lisboa, PT (rmelo@fmh.ulisboa.pt) ORCID: 0000-0002-7264-1793.

Article History

Received 29 January 2017
Accepted 9 June 2017
Published 1 September 2017

Keywords

music school
sound pressure
teaching
NIHL
hearing conservation

DOI:


[10.24840/2184-0954_001.001_0005](https://doi.org/10.24840/2184-0954_001.001_0005)


ISSN:

2184-0954

Type:

Research Article

 Open Access

 Peer Reviewed

 CC BY

Abstract

Musical instruments and singers' voices can reach high sound pressure values representing a risk to hearing health, which is of particular relevance for music teachers. Therefore, the potential risk of hearing damage among music teachers in a university school of music was assessed. Twenty teachers completed all phases of the study. Sound pressure levels were measured with a sound meter and daily noise exposure levels were computed and compared with legal reference values in force. Three types of hearing exams were administered to all teachers by health technicians. Most teachers (75%) were subjected to daily noise exposure levels below 80 dB(A). Teaching to play brass instruments appears to be the most risky activity. Only three subjects were diagnosed with noise-induced hearing loss, which cannot be exclusively ascribed to occupational activities because they are involved in extracurricular activities. Increased sample size and the use of noise dosimetry would have improved the study conclusions.

1. INTRODUCTION

While age is the most important predictor of hearing loss (presbycusis), noise-induced hearing loss (NIHL) remains highly prevalent in occupational settings, and is increasingly caused by social noise exposure. Around 27% of the working population of the EU28 member states is exposed on a daily basis to sound pressure levels that could potentially cause NIHL (Parent-Thirion, et al., 2016).

Noise is often described as unwanted and unpleasant sound, ranging from quiet but annoying to loud and harmful. NIHL may be triggered by a single exposure to an intense sound like in an explosion or a gunshot, or by steady-state long term exposure to noise with sound pressure levels above 75-80 dB(A), such as in industrial settings (Basner, et al., 2014; Lie, et al., 2016).

Presenting an insidious onset, NIHL gradually develops over the years and its presence and severity are difficult to notice without hearing tests. In age-related hearing loss, audiograms present a descending pattern revealing reduced hearing acuity in higher frequencies. In the case of NIHL, the audiometric profile presents a sharp depression (often named notch or V-shape dip) between 3 kHz and 6 kHz. NIHL audiometric patterns are mostly bilateral and symmetrical but may reveal predominantly unilateral loss due to directional noise exposure

(Chasin, 2010; Hong, Kerr, Poling & Dahr, 2013). However, gaps remain in knowledge on how noise and age interact and sometimes the signs from presbycusis resemble or mask those of NIHL and vice versa.

Music is not conventionally thought as noise. In fact it is generally considered a pleasant and enjoyable sound. Nevertheless, it can reach considerably high sound pressure levels and therefore be implicated as a causal factor of hearing loss (Chesky, 2008; Zhao, Manchaiah, French & Price, 2010). Some audiologists and hearing conservationists even use the term music-induced hearing loss (Chesky, 2008).

Non-occupational examples of music exposure include attending nightclubs (Helleman & Dreschler, 2015) and concerts (Zhao, et al., 2010) and listening to personal music players (Levey, Levey & Fligor, 2011; Zhao, et al., 2010) on a voluntary basis. On the other hand, occupational situations expose musicians, music students and music teachers to noise on a daily basis for professional reasons (Zhao, et al., 2010).

NIHL has a profound impact on individual's quality of life in different ways, namely through sleep disturbances and communication interference, affecting social integration. In occupational settings, it may compromise safety, and job performance is also affected. This is particularly relevant for music teachers, considering that their professional activity requires accurate sound perception in terms of pitch, loudness and timbre. Yet, research concerning hearing loss among these professionals has been scarce, probably because the cumulative nature of sound exposure is often misunderstood among them (Chesky, 2008) and it is difficult to determine a teacher's typical day/week (Behar, et al., 2004). The activities distribution varies from teacher to teacher, from day to day and even from week to week. Additionally, extracurricular activities such as rehearsals and performances add to the noise exposure and it is known that the risk of overexposure to sound results from the combination of sound pressure level with exposure time.

There is abundant literature dealing with noise exposure and NIHL in symphony orchestra musicians (Jansen, Helleman, Dreschler & Laat, 2009; Schmidt, et al., 2011; Pawlaczyk-Łuszczńska, Zamojska, Dudarewicz & Zaboriowski, 2013; Penzkofer, Finé & Kluth, 2015; Rodrigues, Freitas, Neves & Silva, 2014; Russo, Behar, Chasin & Mosher, 2013; Zhao, et al., 2010) and rock/jazz musicians (Kähäri, Zachau, Eklof, Sandsjö, Möller, 2003; Zhao, et al., 2010).

As for educational environments, susceptibility to NIHL has been identified in music students (Lüders, de Oliveira Gonçalves, de Moreira Lacerda, Ribas & Conto, 2014; Phillips, Heinrich & Mace, 2010).

The few published studies concerning noise exposure of music teachers cover those of elementary and high schools (Behar, et al., 2004; Cutietta, Klich, Royse & Rainbolt, 1994; Kozłowski & Młyński, 2014; Zivkovic & Pityn, 2004). A single study accomplished in a university school was found (Mace, 2006) and refers to the existence of potential risk for NIHL. More recently, teachers from a music academy (Maffei, Iannace & Masullo, 2011) and from a conservatory (Roggio, Maffei, Iannace, Serra & Biassoni, 2010) were also studied.

One would say that students from lower levels are likely to be technically less advanced and rather enthusiastic when playing their instruments than older ones. Still, equally high values were obtained when teaching university students or at music academies or conservatoires (Mace, 2006; Maffei et al., 2011; Roggio, et al., 2010).

Maffei et al. (2011) argue that the music piece and the way it is played have a strong influence on noise exposure levels. On the other hand, Mace (2006) states that the performance level of students has little if any effect. In fact, Behar et al. (2004) defend that noise exposure levels are mostly dependent on the type of music being played than on the students' skills.

Nevertheless, there is a lack of information regarding university-level music teachers' exposure to noise and NIHL prevalence among them. Factors of concern that should be analyzed include teaching specialization (e.g. brass, keyboard, string, woodwind, percussion, and singing), teaching activity (e.g. individual classes *versus* group classes), number of students per class, performance level of participants, as well as the type of music played (Mace, 2006).

The main purpose of this study was to determine daily noise exposures of music teachers, in a university school of music in Lisbon (Portugal) and assess their hearing health. Additionally, and following the obtained results, guidance regarding hearing conservation was to be provided.

The research questions of the study were as follows:

- Do university music teachers experience daily noise levels exceeding the reference levels, established by the European Directive on noise, in individual and group teaching environments?
- How do the following variables affect daily noise exposures?
 - Teaching specialization (voice, keyboard, string, brass, woodwind, etc.);
 - Class type (individual, group, both).
- Do these teachers present permanent hearing threshold shifts and any symptoms related to hearing loss?

2. MATERIALS AND METHODS

Although all 37 eligible full-time music teachers from a university school of music have been invited to participate in this study, only 26 (70.3%) accepted the invitation. From these, 6 did not complete all phases, meaning that only 20 (54.1%) integrated the sample.

Daily activities of these teachers included classes where students played individually or in ensembles, individual singing and choir classes, lectures and others dedicated to composition techniques, and music listening and analysis. In some classes teachers play along with the student(s) or simply play the piano. Students played different keyboard instruments (piano and harpsichord), brass instruments (saxophone, trombone, euphonium, trumpet, tuba and flugelhorn), percussion instruments (maracas, triangle and reco-reco), woodwind instruments (Bisel flute and clarinet), and a string instrument (cello).

The objectives of the study, the measurement procedures and the advantages of taking the hearing tests were explained to all participants. After assuring them the study was anonymous and their names would not be revealed, they signed an informed written consent.

A self-administered questionnaire was developed and made available to participants through Google Forms aiming at 1) characterizing the participants, their past jobs, seniority at work and their actual daily activities; 2) identifying the main self-reported symptoms associated with hearing loss; and 3) assessing the use of hearing protective devices by them.

Sound measurement equipment included a class 1 sound meter type 2260 and a sound calibrator type 4231, both from Brüel & Kjær. Measurements were repeated 3 times in each class, in accordance with the [ISO 9612 \(2009\)](#) guidelines, and lasted 5 minutes minimum until the reading values stabilized.

A-weighted equivalent continuous noise level ($L_{A,eq}$) and peak sound level (L_{Cpeak}) were obtained. With the knowledge of the noise level for a particular activity and the duration of activities in an average day (provided by each teacher), it was possible to estimate the daily noise exposure ($L_{EX,8h}$) using equation (1).

$$L_{EX,8h} = 10 \log \left[\frac{1}{8} \left(\sum_{i=1}^n t_i \cdot 10^{L_{A,eq,i}/10} \right) \right] \quad (1)$$

Where:

t_i – duration of activity i ;

$L_{A,eq,i}$ - A-weighted equivalent continuous noise level of activity i .

The present study was solely based on measuring noise from classes because it is quite difficult to define a typical day of activities and there were no noise dosimeters available. All other activities in school were assumed to produce $L_{A,eq}$ values under 70 dB(A).

As there is no particular criterion to assess noise exposure risk of music teachers in Portugal or in Europe it was decided to follow that of the European Directive 2003/10/CE (2003), in force in Portugal since 2006 (Exposure limit values - ELV: $L_{EX,8h}=87$ dB(A), $L_{Cpeak}=140$ dB(C); Upper Exposure Action Values - UEAV: $L_{EX,8h}=85$ dB(A), $L_{Cpeak}=137$ dB(C); Lower Exposure Action Values - LEAV: $L_{EX,8h}=80$ dB(A), $L_{Cpeak}=135$ dB(C)).

To avoid temporary shifts in hearing sensitivity participants were asked to avoid music classes, rehearsals and performances for at least 12 hours before the administration of the hearing tests by health technicians. The data were collected under the same testing conditions.

All participants' ear canals and tympanic membrane were examined by means of an otoscope to ensure they were free from any obvious problems prior to performing a tympanogram and a pure tone audiometry.

A tympanometer from Grason Stadler, model Gsi38, was used to test the condition of the middle ear and the mobility of the eardrum and the conduction bones. This examination allows differentiating conductive from sensorineural hearing disorders.

Air conduction pure tone audiometry relied on an audiometer from Madsen, model Midimate 622. This hearing test was used to identify hearing threshold levels of the participants, particularly at 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz, enabling the determination of the degree, type and configuration of hearing loss.

The hearing loss categories established by the Bureau International d'Audiophonologie (BIAP, 1996) were applied: normal/subnormal hearing, mild, moderate, severe, very severe and total hearing loss.

All audiograms were inspected for contours indicating either presbycusis or NIHL, i.e. hearing loss evidence particularly located at higher frequencies.

Noise measurement data analysis relied on Protector Software Type 7825, from Brüel & Kjær. The Statistical Package for the Social Sciences (SPSS 21) was used for statistical descriptive analyses based on measures of location and dispersion.

3. RESULTS AND DISCUSSION

Initial concern was raised regarding the risk of NIHL among university music teachers, leading to measurement of noise levels in classes.

The 20 teachers that completed all phases of the study were between 30 and 65 years old (47.7 ± 9.8 years) and only 4 (20%) were females.

Eight teachers were exclusively involved in individual classes whereas 10 taught group classes and the other 2 were engaged in both types of class. Activities performed by them vary throughout the day and the week, and sometimes throughout the month. Therefore, it is difficult to define a typical working day with a typical noise exposure pattern. As reported by them, mean daily teaching time was 5.95 ± 1.94 h and ranged between 2 and 8 h. These values allowed computing the daily noise exposure per type of class and per teaching specialization.

The effect of the type of class on daily noise exposure was examined in Figure 1, where each column corresponds to a different teacher.

It can be seen that daily noise exposure is below the LEAV of 80 dB(A) for most teachers (15) and never exceeds the ELV of 87 dB(A). The two highest values were above the UEAV of 85 dB(A) and occurred for one group class teacher (85.6 ± 1.5 dB(A)) and for another one involved in both types of class (86.6 ± 1.6 dB(A)). Values below 70 dB(A) were registered for teachers engaged either in individual or group classes.

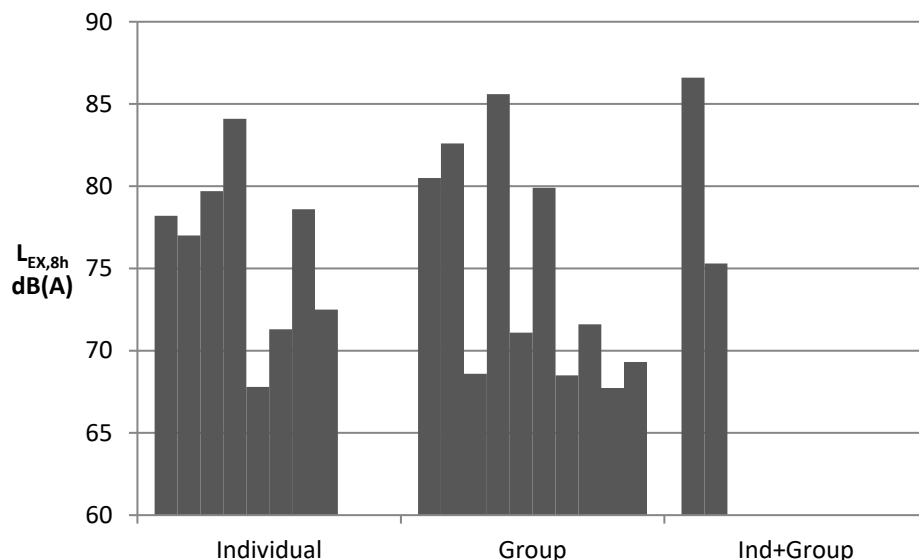


Figure 1. Daily noise exposure per class type.

Participants have different teaching specializations and apart from those teaching to play different musical instruments (12), some are totally dedicated to singing classes (one individually and 3 in choirs), others (3) exclusively provide supporting lectures and one is responsible for the composition techniques' classes.

The effect of teaching specialization on daily noise exposure was examined in Figure 2, where each column corresponds to a single teacher.

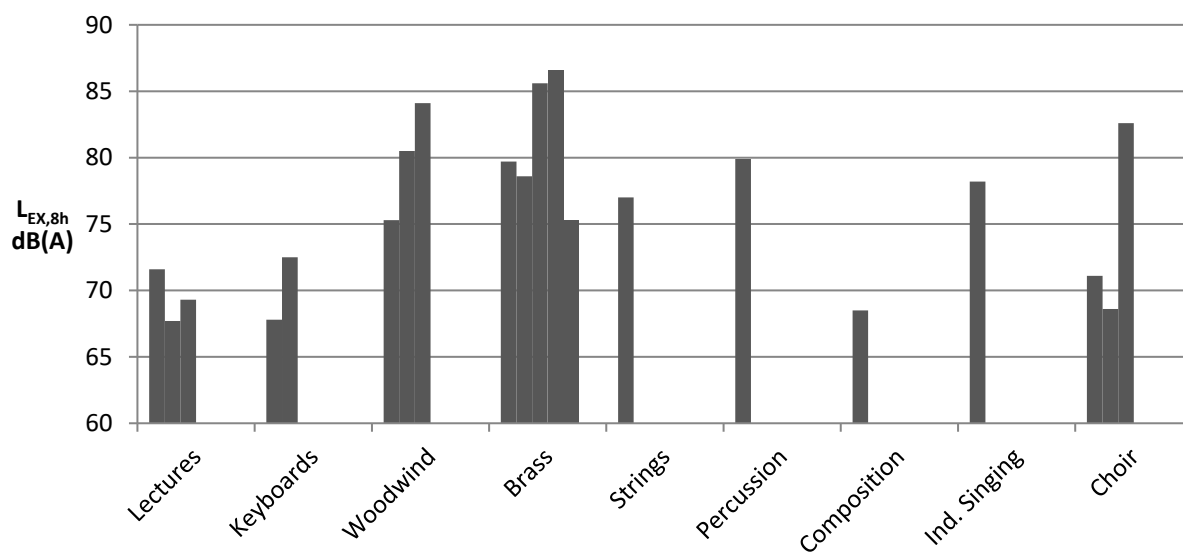


Figure 2. Daily noise exposure according to the category of instruments played and class activities.

It is obvious that most activities promote daily noise exposures under 80 dB(A), particularly those not involving musical instruments nor singing: lectures (3) and composition techniques' classes. On the other hand, the highest values were obtained for those teaching brass instruments, clarinet (84.1±2.0 dB(A)) and choirs (82.6±2.0 dB(A)). Euphonium, tuba, trumpet and flugelhorn were the brass instruments responsible for values exceeding the UEAV. The ELV of 87 dB(A) was never reached.

Sound peak level was below the LEAV of 135 dB(C) in all situations.

Following the administration of the 3 hearing tests to all teachers; it was found that only one of them presented exostoses whereas wax was detected in seven (either in one or in both

ears). Tympanograms assured that none of them presented conductive hearing loss. Most teachers' audiograms revealed normal hearing in the left ear (15) and in the right ear (14). However, mild sensorineural hearing loss was diagnosed for 2 (left ear) and 3 (right ear) teachers, which represents an average tone loss between 21 dB and 40 dB. They were all males, aged 52, 55 and 63. Two audiograms displayed hearing loss below 20 dB (one in both ears and the other one only in the right ear), which corresponds to subnormal hearing according to [BIAP's \(1996\)](#) classification.

The analysis of data collected by means of the self-administered questionnaire revealed that 17 teachers participate in extracurricular activities, which include private lessons, self-practicing or even participation in live performances. Seven of them do it on a daily basis whereas the others do it less frequently: every week (7), every month (3).

Eight teachers were already engaged in the teaching career before their admission in this particular school, whereas 9 used to play in orchestras. Twelve of them have been working in this school for more than 10 years and only 2 do it for less than 5 years.

As for the self-reported signs and symptoms, tinnitus was referred by 5 while 2 mentioned to have difficulties in following a conversation. Sleeping disorders such as having difficulty to fall asleep were identified by 8 teachers. In terms of sleep quality, sleep duration and sleep depth were both ranked as bad by 5 and 4 teachers, respectively.

The use of hearing protection was considered relevant by 18 teachers, but only one wears ear protectors, chosen and bought by him. Nevertheless, 16 of them consider this personal protective equipment would interfere significantly with their daily activities.

4 DISCUSSION

Class type does not seem to play a relevant role on the daily noise exposure as different levels were found for teachers involved exclusively in individual classes, or in group classes or even in both types of classes. Nevertheless, values were below the LEAV for 75% of the teachers and lower than those found by [Mace \(2006\)](#). In her study daily exposure was above the UEAV of 85 dB(A) for 33% and 61% of the teachers participating in individual and group classes, respectively.

The UEAV was exceeded in 2 brass instruments' classes and the obtained values were always higher than 75 dB(A). However, other studies have shown that teaching brass instruments is likely to produce daily noise exposure values above the ELV ([Kozłowski & Młyński, 2014](#); [Mace, 2006](#); [Maffei et al., 2011](#); [Roggio et al., 2010](#); [Zivkovic & Pityn, 2004](#)). This might be due to two important characteristics of these instruments: they are directional for higher frequency energy and this high-frequency energy is significantly more intense than the lower frequency fundamental energy ([Chasin, 2010](#)).

In classes dedicated to composition techniques, piano or recorded music is played, and students sing or clap hands to mark rhythm. Still, daily noise exposures did not exceed the LEAV. In contrast, teaching flute and clarinet along with choir classes resulted in daily noise exposures above the LEAV.

The low values registered for sound peak level in all situations concurs with those published by [Kozłowski and Młyński \(2014\)](#), [Maffei et al. \(2011\)](#) and [Roggio et al. \(2010\)](#). Nevertheless, higher values were reached in piano and flute classes in these two last studies. [Behar et al. \(2004\)](#), [Mace \(2006\)](#) and [Zivkovic and Pityn \(2004\)](#) did not report sound peak levels.

Finding of evidence of NIHL among university-level music teachers seems no different from that of the general population. In fact, those diagnosed with mild hearing loss are males aged 52, 55 and 63, respectively, which is in agreement with the fact that men are more likely to experience NIHL than women ([Cutietta, et al., 1994](#)). Nevertheless, they presented daily noise exposures below the LAV and taught brass instruments, woodwind instruments and singing, respectively. Furthermore, as most of the teachers participate in extracurricular activities, their susceptibility to NIHL cannot be ascribed solely to their job.

Self-reported symptoms are in accordance with the audiograms' results, with a small percentage of teachers complaining of tinnitus, having difficulties in following a conversation or sleeping disorders such as having difficulty to begin to sleep.

From the noise measurement results previously described, and despite not having many cases of NIHL, we can conclude that there is a potential risk of hearing loss among teachers of this university school of music. Therefore, measures should be implemented for noise reduction and NIHL prevention.

Table 1 summarizes a set of measures that could be fulfilled either by the teachers themselves or the employer.

Table 1. Control measures to be implemented for noise reduction and NIHL prevention.

What employees can do	What employers can do
<ul style="list-style-type: none"> • Reduce the number of students per class; • Ask students to play softly in class; • Select adequate music pieces; • Increase the distance between the teacher and student(s); • Use larger classrooms with absorbent materials; • Enjoy pauses in quiet places; • Wear musician's ear plugs in the noisier classes. 	<ul style="list-style-type: none"> • Change classroom's layout; • Provide larger classrooms acoustically treated; • Provide quiet spaces for employees' pauses; • Provide a hearing conservation program, including periodical audiometric testing and training; • Provide information about hearing loss and how to prevent it to students and teachers; • Organize weekly timetables; • Provide adequate (flat attenuation) ear plugs to teachers.

The most effective noise control measure is noise source elimination, which is impossible to accomplish in a music school when we intend to prevent music-induced hear loss.

The next step would be reducing noise at the source, which can be achieved by asking students to play softly (saving their enthusiasm for performances), selecting adequate music pieces and reducing the number of students in class.

Classrooms definitely play a relevant role and attention should be given to their arrangement, dimensions and acoustic properties (Chesky, 2008, 2011; Kozłowski & Młyński, 2014; Koskinen, Toppila & Olkinuora, 2010; Zha, Fuchs & Drotleff, 2002). To achieve lower sound pressure levels: 1) ceilings and walls should be fitted with absorbing panels; 2) floors should have carpets or rugs; 3) blank walls and windows should be covered with curtains. Providing larger classrooms will allow teachers to place themselves at a safer distance from the instruments but should not be used to increase the number of students per class.

Organizational approaches also bring benefits to teachers. Spreading the noisiest classes throughout the week and sharing them equally among the teaching staff are vital. Teachers also should have a quiet room to take their pauses.

Raising awareness of the harmful potential of musical instruments and singers' voices regarding the sound pressure levels they can achieve is imperative. Exposure in this type of environment is usually intermittent and not continuous as it is in industry leading to a misinterpretation of the cumulative nature of sound exposure.

A hearing conservation program should include periodic administration of hearing exams to all teachers exposed to higher noise levels.

Finally, hearing protection should be considered, particularly in classes known to produce higher noise levels. There are earplugs specifically designed for musicians, presenting flat attenuation, either pre-molded or custom-molded. Despite being more expensive, these last ones offer protection levels between 9 dB and 25 dB (ER-9; ER-15 and ER-25) and present little occlusion effect (Chasin, 2010).

5 CONCLUSIONS

Because an acute sense of hearing is fundamental for music teachers while teaching individual or ensemble classes, rehearsing and performing, two different approaches were adopted in this study: sound pressure level measurement and hearing level assessment.

Daily noise exposures of university music teachers may be lower than those previously reported by other authors. Nevertheless, their values can and in some cases do exceed the LEAV and the UEAV, meaning that intervention is required.

No significant effect of the type of teaching activity on daily noise exposure was found. However, brass instruments' teachers seem to be the ones most likely at risk.

Only three cases of NIHL were identified and may be due to extracurricular activities teachers are engaged in, mostly to increase their income, and not depend exclusively on occupational exposure. Besides, an interaction between noise and age may have happened since older people are more prone to present increased hearing threshold shifts.

The small dimension of our sample and the exclusive use of a sound meter instead of a dosimeter are two major limitations of this study that reduce the possibility of generalizing these conclusions. However, additional knowledge was presented to the scarce information available concerning noise exposure of this particular group of teachers.

REFERENCES

- Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., & Stansfeld, S. (2014). Auditory and non-auditory effects of noise on health. *The Lancet*, *383*(9925), 1325-1332. DOI: [10.1016/S0140-6736\(13\)61613-X](https://doi.org/10.1016/S0140-6736(13)61613-X).
- Behar, A., MacDonald, E., Lee, J., Cui, J., Kunov, H., & Wong, W. (2004). Noise exposure of music teachers. *Journal of Occupational and Environmental Hygiene*, *1*(4), 243-247. DOI: [10.1080/15459620490432178](https://doi.org/10.1080/15459620490432178).
- BIAP (1996, October 26). Recommendation n. 02/1 bis Audiometric classification of hearing impairment. Retrieved January 19, 2017 from: <https://www.biap.org/en/component/content/article/65-recommendations/ct-2-classification/5-biap-recommendation-021-bis>.
- Chasin, M. (2010). Hear the music: Hearing loss prevention for musicians (4th edition). Toronto: Musician's Clinics of Canada. Retrieved January 12, 2017 from: http://marshallchasinassociates.ca/pdf/Hear_the_Music_2010.pdf.
- Chesky, K. (2008). Preventing music-induced hearing loss. *Music Educators Journal*, *94*(3), pp. 36-41. DOI: [10.1177/002743210809400308](https://doi.org/10.1177/002743210809400308).
- Chesky, K. (2011). Schools of music and conservatories and hearing loss prevention. *International Journal of Audiology*, *50*(Sup1), S32-S37. DOI: [10.3109/14992027.2010.540583](https://doi.org/10.3109/14992027.2010.540583).
- Cutietta, R.A., Klich, R.J., Royse, D., & Rainbolt, H. (1994). The incidence of noise-induced hearing loss among music teachers. *Journal of Research in Music Education*, *42*(4), 318-330. DOI: [10.2307/3345739](https://doi.org/10.2307/3345739).
- Directive 2003/10/EC. (2003). Directive of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise) (Seventeenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC). *Official Journal of the European Union*, *L42*(15 February 2003), 38-44.
- Helleman, H.W., & Dreschler, W.A. (2015). Short-term music-induced hearing loss after sound exposure to discotheque music: The effectiveness of a break in reducing temporary threshold shift. *International Journal of Audiology*, *54*(Sup1), S46-S52. DOI: [10.3109/14992027.2014.974114](https://doi.org/10.3109/14992027.2014.974114).
- Hong, O., Kerr, M.J., Poling, G.L., & Dhar, S. (2013). Understanding and preventing noise-induced hearing loss. *Disease-a-Month*, *59*(4), 110-118. DOI: [10.1016/j.disamonth.2013.01.002](https://doi.org/10.1016/j.disamonth.2013.01.002).
- ISO (2009). ISO 9612: 2009 Acoustics -- Determination of occupational noise exposure -- Engineering method. Geneva: International Organization for Standardization.

- Jansen, E.J.M., Helleman, H.W., Dreschler, W.A., & Laats, J.A.P.M. (2009). Noise induced hearing loss and other hearing complaints among musicians of symphony orchestras. *International Archives of Occupational and Environmental Health*, 82(2), 153-164. DOI: [10.1007/s00420-008-0317-1](https://doi.org/10.1007/s00420-008-0317-1).
- Kähäri, K., Zachau, G., Eklof, M., Sandsjö, L., & Möller, C. (2003). Assessment of hearing and hearing disorders in rock/jazz musicians. *International Journal of Audiology*, 42(5), 279-288. DOI: [10.3109/14992020309078347](https://doi.org/10.3109/14992020309078347).
- Koskinen, H., Toppila, E., & Olkinuora, P. (2010). Facilities for music education and their acoustical design. *International Journal of Occupational Safety and Ergonomics*, 16(1), 93-104. DOI: [10.1080/10803548.2010.11076831](https://doi.org/10.1080/10803548.2010.11076831).
- Kozłowski, E., & Młyński, R. (2014). Effects of acoustic treatment on music teachers' exposure to sound. *Archives of Acoustics*, 39(2), 159–163. DOI: [10.2478/aoa-2014-0019](https://doi.org/10.2478/aoa-2014-0019).
- Levey, S., Levey, T., & Fligor, B.J. (2011). Noise exposure estimates of urban MP3 player users. *Journal of Speech, Language, and Hearing Research*, 54(1), 263-277. DOI: [10.1044/1092-4388\(2010/09-0283\)](https://doi.org/10.1044/1092-4388(2010/09-0283)).
- Lie, A., Skogstad, M., Johannessen, H.A., Tynes, T., Mehlum, I.S., Nordby, K.C., Engdahl, B., & Tambs, K. (2016). Occupational noise exposure and hearing: a systematic review. *International Archives of Occupational & Environmental Health*, 89(3), 351–372. DOI: [10.1007/s00420-015-1083-5](https://doi.org/10.1007/s00420-015-1083-5).
- Lüders, D., de Oliveira Gonçalves, C.G., de Moreira Lacerda, A.B., Ribas, Â., & Conto, J. (2014). Music students: conventional hearing thresholds and at high frequencies. *Brazilian Journal of Otorhinolaryngology*, 80(4), 296-304. DOI: [10.1016/j.bjorl.2014.05.010](https://doi.org/10.1016/j.bjorl.2014.05.010).
- Mace, S.T. (2006). A descriptive analysis of university music performance teachers' sound-level exposures during a typical day of teaching, performing, and rehearsing. In *Proceedings of the 9th International Conference on Music Perception and Cognition* (pp 271-277). Bologna, Italy.
- Maffei, L., Iannace, G., & Masullo, M. (2011). Noise exposure of physical education and music teachers. *Noise & Vibrations Worldwide*, 42(1), 9-16. DOI: [10.1260/1475-4738.10.4.41](https://doi.org/10.1260/1475-4738.10.4.41).
- Parent-Thirion, A., Biletta, I., Cabrita, J., Vargas, O., Vermeylen, G., Wilcynska, A., & Wilkens, M. (2016). 6th European working conditions survey. Luxembourg: European Foundation for the Improvement of Living and Working Conditions.
- Pawlaczyk-Łuszczczyńska, M., Zamojska, M., Dudarewicz, A., & Zaboriński, K. (2013). Noise-induced hearing loss in professional orchestral musicians. *Archives of Acoustics*, 38(2), 223-234. DOI: [10.2478/aoa-2013-0027](https://doi.org/10.2478/aoa-2013-0027).
- Penzkofer, M., Finé, F., & Kluth, K. (2015). Risks to the hearing of musicians – Subjective and objective evaluation of sound exposures in a non-professional orchestra. *Procedia Manufacturing*, 3(AHFE), 4485-4492. DOI: [10.1016/j.promfg.2015.07.462](https://doi.org/10.1016/j.promfg.2015.07.462).
- Phillips, S.L., Heinrich, V.C., & Mace, S.T. (2010). Prevalence of noise-induced hearing loss in student musicians. *International Journal of Audiology*, 49(4), 309-316. DOI: [10.3109/14992020903470809](https://doi.org/10.3109/14992020903470809).
- Rodrigues, M.A., Freitas, M.A., Neves, M.P., & Silva, M.V. (2014). Evaluation of the noise exposure of symphonic orchestra musicians. *Noise & Health*, 16(68), 40-46. DOI: [10.4103/1463-1741.127854](https://doi.org/10.4103/1463-1741.127854).
- Roggio, I., Maffei, L., Iannace, G., Serra, M., & Biassoni, C. (2010). Noise exposure analysis on teachers of the state music conservatory "Nicola Sala" of Benevento city, Italy. In *Segundo Congreso Internacional de Acústica UNTREF*, September 8-10, Argentina.
- Russo, F.A., Behar, A., Chasin, M., & Mosher, S. (2013). Noise exposure and hearing loss in classical orchestra musicians. *International Journal of Industrial Ergonomics*, 43(6), 474-478. DOI: [10.1016/j.ergon.2012.11.001](https://doi.org/10.1016/j.ergon.2012.11.001).

- Schmidt, J.H., Pedersen, E.R., Juhl, P.M., Christensen-Dalsgaard, J., Andersen, T.D., Poulsen, T., & Bælum, J. (2011). Sound exposure of symphony orchestra musicians. *Annals of Occupational Hygiene*, 55(8), 893-905. DOI: [10.1093/annhyg/mer055](https://doi.org/10.1093/annhyg/mer055).
- Zha, X., Fuchs, H.V., & Drotleff, H. (2002). Improving the acoustic working conditions for musicians in small spaces. *Applied Acoustics*, 63(2), 203-211. DOI: [10.1016/S0003-682X\(01\)00024-X](https://doi.org/10.1016/S0003-682X(01)00024-X).
- Zhao, F., Manchaiah, V.K.C., French, D., & Price, S.M. (2010). Music exposure and hearing disorders: An overview. *International Journal of Audiology*, 49(1), 54-64. DOI: [10.3109/14992020903202520](https://doi.org/10.3109/14992020903202520).
- Zivkovic, D., & Pityn, P. (2004). Music teachers' noise exposure. *Canadian Acoustics*, 32(2), 84-85.