Dosimeter Sound Level Measurements in Practice Rooms

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Abstract

Previous research suggests that musicians may be particularly susceptible to noise induced hearing loss (NIHL). To date, however, very few studies examined noise exposure acquired by university vocalists as they practice in school practice rooms, many of which may be small and poorly constructed. The purpose of this study was to assess the noise exposure of university singing students (N = 14; n = 4 sopranos, n = 3 mezzo-sopranos, n = 4 tenors, n = 3 basses) during practice times in university designated practice rooms. Each recorded session consisted of a natural, non-guided practice routine, documented by each participant, lasting for a duration of the participant's choosing. In addition, 3 participants (n = 1 soprano, n = 1 mezzo-soprano, n =1 bass) collected data during waking hours for one day. Participants wore Etymotic Personal Noise Dosimeters (Model ER-200D) calibrated according to National Institute of Occupational Safety and Health (NIOSH) recommendations. Acquired data were disaggregated according to allowable daily noise dose percentages, equivalent continuous noise levels (L_{EQ}), voice classification, year in school, and participants' self-reported levels of awareness of NIHL and proactive hearing conservation. Results were discussed in terms of vocal pedagogy, hearing health, and suggestions for future research.

Keywords: hearing, hearing loss, hearing health, singing, dosimeter, noise

Various studies in music and in occupational health assessed the level of potentially harmful noise exposure with musicians and music educators. Many studies (Chesky, 2010; Cook-Cunningham, Grady, & Nelson, 2012; Hayes, 2013; Henoch & Chesky, 2000; Mace, 2005; Phillips & Mace, 2008) suggested that noise dose over time in common musical environments can exceed the recommended standards set out by the National Institute of Occupational Safety and Health (NIOSH). Exceeding these standards can potentially cause noise-induced hearing loss (NIHL), yet the occupation and lifestyle of musicians and music educators is such that they often experience noise doses higher than the recommended standards and therefore incur a risk of NIHL.

Concerts and loud music performances are capable of reaching excessive noise levels on a regular basis, yet it is uncommon for audience members to wear hearing protection. It is possible that many members of the general public are unaware of the risk of exposure to loud music. Beach, Williams, and Gilliver (2012) studied the motivations for clubbers and concert-goers ($N = 20$) who regularly wear hearing protection at loud music performances. Participants ($n = 5$ females, $n = 15$ males) ranging from 21 to 42 years of age described the reasons for wearing hearing protection through structured telephone interviews lasting approximately 20 minutes. All interviews were transcribed verbatim for content analysis, and coded into 23 categories. Results indicated that the participants' primary reason for wearing hearing protection was personal experience of noise-related injury symptoms. Other reasons included awareness of the benefits of earplugs, awareness of the long-term implications of hearing damage, and affinity for music.

Biassoni et al. (2014) studied the auditory function of adolescent males in the general population (*N* = 172) at two ages: 14-15 (test) and 17-18 (retest). Participation decreased dramatically between test and retest, and only a small number (*n* = 59) were retested. Both tests consisted of (a) Auditory State Questionnaire, (b) otoscopic examination, (c) tympanometry, (d) audiometry to determine hearing threshold level (HTL) within the audible spectrum (250-16000 Hz), and (e) transient evoked otoacoustic emissions (TEOAE) to detect mechanical cochlear status. Participants were classified according to their HTL; Group 1 with normal HTL up to 18dB at all frequencies (112 adolescents (test) – 49 adolescents (retest)); Group 2 with slight shift of HTL up to 24dB at least in one frequency (21 adolescents (test) – 4 adolescents (retest)), Group 3 with a significant shift of HTL over 24 dB at least in one frequency (39 adolescents (test) – 6 adolescents (retest)). Due to fewer participants in the retest, only data corresponding to Group 1 were statistically processed and compared with the results of the same adolescents in the test. Results indicated a statistically significant increase of HTL and decrease of TEOAE amplitude between test and retest data for Group 1. Questionnaire data indicated an increase in recreational musical activity from test to retest. Data were discussed in terms of possible correlations.

Some studies tested the extent of Noise-Induced Hearing Loss (NIHL) among orchestral musicians. Axelsson and Lindgren (1981) tested the hearing of orchestral musicians (*N* = 139) and found that 43% (*n* = 59) of these musicians showed mean and individual pure tone thresholds indicating a sensorineural high tone loss, consistent with the effects of noise-induced hearing loss. The extent of participants' high tone loss was greater than expected for their age. A study by Emmerich, Rudel, and Richter (2008) included audiometric and questionnaire data from professional orchestral musicians (*n* = 109) aged 30-69 and student orchestral musicians

attending an academy of music (*n* = 110) aged 11-19. Audiometric data indicated a hearing loss of 15 dB (A) or more in over 50% of the total participants. Questionnaire data indicated very low or no participation in noisy hobbies outside of music, and few indicated the use of hearing protection. Measures to increase awareness of hearing health in musicians and the classifications of hearing loss as an occupational disease were discussed.

Cutietta, Klich, Royse, and Rainbolt (1994) studied the hearing acuity of music teachers (*N* = 104) in vocal (*n* = 55), elementary instrumental (*n* = 11), and high school instrumental (*n* = 38) disciplines. Participants tested for evidence of hearing loss that could be attributed to NIHL based on audiogram readings indicative of a reduction in hearing acuity around 4000 Hz. A clinical audiometer conducted the tests using standardized audiometric procedures. Results indicated that 20 participants (19%) showed signs of possible NIHL. The degree of hearing loss was greater with high school instrumental teachers than the other groups. There was also a possible positive relationship between degree of hearing loss and length of service in the profession; however, individual results varied.

Barlow (2011) examined the pure tone air conduction hearing thresholds of undergraduate popular music students (*N* = 50). Pure tones with frequencies ranging from 0.5-8 kHz and amplitudes of 35 dB were generated using an Oscius Computer Controlled Audiometer with supra-aural earphones. Results indicated that 44% of participants showed signs of audiometric notch at 4-6 kHz, and 16% classified under the UK Occupational Health and Safety guidelines as exhibiting mild hearing loss. Data were analyzed to test for possible noise-induced threshold shifts (NITSs) at specific frequency ranges. Results suggested that NITS was occurring earlier than previously thought.

Awareness of the effects of NIHL and the risk factors associated with it is important for musicians' health. Data from several studies indicated awareness levels of musicians and music educators. O'Brien, Ackermann, and Driscoll (2014) surveyed professional musicians in Australian orchestras regarding their hearing and hearing conservation practices. Participants (N = 367) across eight professional orchestras submitted responses. Eighty percent of respondents reported an awareness of risk of hearing damage in the orchestra, and 43% reported experience with hearing loss at the time of the survey. Sixty-four percent of participants reported wearing hearing protection at least some of the time, but 83% of respondents found this to be difficult or impossible. Hagerman (2013) studied the ability for musicians (N = 22) to estimate their risk of NIHL. Participants wore personal noise dosimeters for two working weeks as they practiced and performed predominantly classical music. Participants also kept a diary of daily activities and indicated what musical activities had noise levels that were potentially harmful to their hearing. Results indicated that approximately half of all participants judged when their musical activities had noise levels that were potentially harmful with reasonable accuracy, and half were inaccurate in their judgement. Albin (2012) examined ensemble conductors (N = 162) who taught at colleges in the United States and held membership with the College Music Society (CMS) for (a) awareness of noise levels in rehearsals, (b) attitudes towards hearing health, and (c) equipment used to monitor sound intensity levels in rehearsals. Data were collected using an online questionnaire created by the researcher and hosted by CMS. Results indicated that 80.2% of participants agreed that sound intensity levels in rehearsals have potential to cause NIHL, but 24.1% "do not know" if their rehearsal activities reach the sound intensity levels capable of causing NIHL. The data also indicated that 54.9% do not know about the resources available at their institutions to increase awareness and reduce risk of NIHL, while 93% have never used a

noise dosimeter, 40% have never had an audiology exam, and 70% have never used hearing protection during rehearsal activities. Responses indicated, however, that conductors have open attitudes towards improved education and awareness of NIHL for colleagues and students.

Many studies used personal noise dosimeters to measure L_{EQ} and/or daily dose percentage in relation to allowable criteria set out by different occupational health bodies, including Occupational Safety and Health Administration (OSHA) and the more conservative National Institute for Occupational Safety and Health (NIOSH). Rodrigues, Freitas, Neves, and Silva (2014) measured noise levels at various locations within a symphonic orchestra using personal dosimeters. Results indicated that brass, woodwind, and percussion players experienced noise levels exceeding an 85 dB (A) L_{EQ}. Sound levels varied by instrument, repertoire, and location within the orchestra. The data indicated that musicians in an orchestra are at risk of NIHL due to high noise exposure.

Hayes (2013) used an Etymotic ER-200D dosimeter to measure the daily dosage incurred by high school band directors ($N = 5$) during a normal day of teaching and extracurricular activities. All participants' doses surpassed NIOSH guidelines, ranging from 3.4x to 20x the daily recommended allowable dose. Similarly, Mace (2005) measured the L_{EQ} sound level exposures and calculated the daily dose percentages of university music performance teachers ($N = 37$) across two work days. These data were compared to both NIOSH and OSHA standards. Each participant wore a Cirrus Research CR:100B doseBadge personal dosimeter set to standards recommended by NIOSH. Participants tested for hearing loss using an audiometer. Participants also recorded their perceptions and background knowledge in hearing health via a questionnaire. Results indicated that 13 participants experienced noise levels that exceeded NIOSH standards in a single day, and that 12 participants experienced noise levels that exceeded

NIOSH standards on average over two days. Results also indicated that five participants experienced noise levels that exceeded OSHA standards in a single day, and that two participants experienced noise levels that exceeded OSHA standards on average over two days. A total of 22 participants tested showed signs of hearing loss with a >15 dB hearing threshold in at least one ear.

Chesky (2010) acquired dosimeter data from two college wind bands (n = 1 symphonic band; n = 1 concert band) engaging in various ensemble activities (n = 43). Each activity lasted 170 minutes. Dosimeters data were collected for each activity and were processed to assess associations with predictor variables, including indicators of time spent at various intensity levels, in order to calculate peak and mean dosage according to NIOSH standards for exposure time. The mean dose for both wind bands per event for the entire sample was 109.5% of the NIOSH recommended daily dose, with a range of 53.8% to 166.9%. The possible impacts on hearing health for each band were discussed. Henoch and Chesky (2000) recorded dosimeter measurements (N = 15) from five different positions within a jazz ensemble over a period of three days. The researchers derived 3-hour and 8-hour dose estimates from these measurements and compared these estimations to OSHA standards. Ten of the 15 cases exceeded allowable exposure limits for 3-hour periods, and all 15 cases did so for 8-hour periods. The researchers discussed possible reasons for levels in specific locations within the ensemble (e.g. section leader chairs) and potential impact of the noise levels on NIHL.

Miller, Stewart, and Lehman (2007) measured the noise exposure of student musicians (N = 27) during practices and sporting events at which they performed. These data were compared to OSHA and NIOSH criteria using 8-hour time-weighted averages and daily dose percentages. Results indicated that participants' daily dose percentages exceeded the recommended maximum

for both measurement criteria. Participants also answered questions about noise exposure and hearing health. Most participants (74%) reported having been taught about the effects of excessive noise exposure, although less than one-third wore hearing protection when playing their instrument, and those that did so wore it infrequently. Sixty-three percent of participants reported experiencing tinnitus after exposure to loud music.

NIHL may be a potential risk for all musicians, including singers. Hu et al. (2015) reviewed medical records from patients (N = 172) who had received an audiogram and videostroboscopy within the last 3 years. All participants identified as singers. The records described the types of hearing loss experienced by singers, and identified risk factors associated with hearing loss in singers. Results indicated that 17.5% (n = 31) showed signs of hearing loss. Statistical significance was found with age and male sex, indicating general hearing loss with singers and non-singers. Bilateral sensorineural was found to be the most common type of hearing loss with singers.

Cook-Cunningham, Grady, and Nelson (2012) documented hearing doses for university choral students (N = 4) in rehearsals and performances of opera choruses. Participants also completed questionnaires that solicited their perceptions of hearing and singing voice status after each data collection. Results indicated that three of the four participants exceeded the NIOSH recommended daily dose for an 8-hour period in at least one session; however perceptual data indicated a lack of singer awareness of the dose they acquired.

Environment and room dimensions could potentially have a significant impact on the L_{EQ} levels experienced by musicians. Phillips and Mace (2008) measured the sound levels of music students (N = 50) from five different instrument groups (brass (n = 10), wind (n = 10), string (n = 10), percussion (n = 10), and voice (n = 10)) in university practice rooms. Participants completed

a questionnaire instrument to solicit practice habit information. L_{EQ} was measured and an estimated dose was calculated to match the mean practice duration for each instrument group. The researchers suggested that if a single mean-duration practice session was coupled with an approximately one-hour ensemble rehearsal of a similar L_{EQ} measurement, then 22 participants would exceed their daily recommended dose with those two sessions alone.

Daugherty, Nelson, Rollings, Grady, and Scott (2015) measured the noise levels experienced by graduate teaching assistants in voice (N = 14; n = 9 females, n = 5 males) in studio practice rooms. In addition, two participants (one male, one female) wore dosimeters for a full day for reference. Results indicated that cumulative noise doses acquired by the instructors while teaching one of the 15 single, 1-hour lessons ranged from 7% - 76% of the daily allowable dose (M = 33%), and L_{EQ} levels ranged from 82.82 - 93.69 dB (A) (M = 88.16 dB (A)). For the six, contiguous 2-hour teaching periods recorded (12 lessons, each period in the same room), cumulative noise doses ranged from 23% - 210% of the daily allowable dose (M = 86.67%), and L_{EQ} levels ranged from 84.81 - 94.24 dB (A) (M = 89.13 dB (A)). For the two, contiguous 3-hour teaching periods recorded (6 lessons), instructor acquired cumulative noise doses ranged from 28% - 81% of daily allowable dose (M = 55%), with L_{EQ} levels ranging from 84.06 - 88.50 dB (A) (M = 86.28 dB (A)). Data acquired from one instructor who taught four 5 contiguous lessons indicated that during this period she acquired 290% of her daily allowable noise dose, with a mean L_{EQ} level of 92.53 dB (A).

To date, few studies have investigated the sound level measurements of singers in practice settings. The purpose of this study was to assess the noise exposure of university singing students (N = 14; n = 4 sopranos, n = 3 mezzo-sopranos, n = 4 tenors, n = 3 basses) during practice times in university designated practice rooms. The following research questions guided this study:

1. Do the noise levels of university singers' practice sessions in university-designated practice rooms exceed the NIOSH recommended daily dose for measured L_{EQ} levels?
2. Do perception data indicate an awareness of noise levels and potential risk of hearing loss by university singers practicing in university-designated practice rooms?

Method

An institutional review board (IRB) process designed to ensure ethical treatment of participants granted approval for all procedures of this study. With IRB approval, participants understood beforehand that the purpose of the study was to measure the equivalent continuous noise levels (L_{EQ}) of their individual practice sessions in university designated practice rooms.

Participants

The large group of participants consisted of university singing students (N = 14; n = 4 sopranos, n = 3 mezzo-sopranos, n = 4 tenors, n = 3 basses), who would provide data from practice room sessions, and also a subgroup (N = 3; n = 1 soprano, n = 1 mezzo-soprano, n = 1 bass) from within the large group, who would also provide data on a full day of voice use in addition to data from practice rooms.

Materials and Procedures

Venue(s). Participants freely chose a university designated practice room of their preference, to allow for a natural, non-guided approach to practice and data collection. The specific room that was selected for each session was recorded. The average dimensions of each practice room were 8 x 8 x 10 ft.

Equipment. An ER-200D Personal Noise Dosimeter (Etymotic Research Inc.) was used to record every session based on findings in a study by Cook-Cunningham (2014) on the validity of measurement data from personal noise dosimeters. This dosimeter conforms to ANSI S1.25-

1991 (R2002) Specifications for Personal Noise Dosimeters and NIOSH Criteria for a Recommended Standard (NIOSH, 1998). The dosimeter can be calibrated to NIOSH or OSHA standards. The dosimeter was calibrated to the more conservative NIOSH standard with a 100% daily dose equal to an eight-hour exposure to a continuous 85 dB (A) noise and a 3 dB exchange rate. The calibration accuracy was ± 2.5 dB (A). The dosimeter incorporated an Omni-directional microphone (flat from 100 Hz to 15 kHz). The dosimeter obtained dose values every 220 milliseconds, averaged over a 3.75-minute interval and saved in non-volatile memory (16 times per hour). The threshold for measurement was 75 dB. After each trial, information extracted from the dosimeters included: (a) run length (HH:MM:SS), (b) final dose percentage, (c) overall L_{EQ} (A-weighted continuous equivalent sound level) in dB, and (d) dose and L_{EQ} values for each 3.75-minute time block. Data were extracted from the device using Etymotic's ER-200D Utility Suite for Microsoft Windows. Dosimeter placement on participants' bodies and the distance from dosimeter microphone to the ear of each participant remained consistent through all trials for each participant. Participants wore the dosimeter attached to their clothing on their right side collarbone area, at the same distance from their right ear for each acquisition period. Participants rehearsed and practiced with their own natural, non-guided routine. The dosimeters began recording at the beginning of the natural, non-guided practice session and recorded the entire session.

Session forms. Participants completed and submitted to the researchers a short form for each practice session. This form indicated (a) the specific practice room, (b) the duration of their overall practice session, and (c) an approximation of singing activities and their durations within the practice session.

Participant questionnaire. Following the conclusion of dosimeter data collection, each participant was issued a brief questionnaire using Likert-type responses to questions regarding their knowledge of and attitudes towards Noise-Induced Hearing Loss (NIHL), precautionary steps to prevent NIHL, NIOSH, and school policies towards adhering to NIOSH standards and NIHL prevention.

Results

Results are presented in order of research questions posed for this investigation.

Research Question 1

The first research question asked if noise levels with university singers practicing in university-designated practice rooms exceeded the NIOSH recommended daily dose for measured L_{EQ} levels. Table 1 shows the L_{EQ} and daily dose percentage for each recorded practice session.

Table 1

L_{EQ} and Daily Dose Percentage for Each Recorded Practice Session

Participant	**Session**	**Room**	**Duration (HH:MM:SS)**	**L_{EQ} (dB)**	**Dose (%)**
S1	1	512	00:14:20	105.7	360
S1	2	515	00:28:09	98.36	130
S2	1	560	00:54:02	100.1	370
S2	2	530	00:54:15	90.13	37
S3	1	512	00:25:42	102.84	330
S4	1	512	00:14:01	98.47	66
S4	2	546	00:10:36	99.49	63
M1	1	560	00:26:02	104.88	540
M1	2	512	00:20:24	102.15	220
M1	3	583	00:18:60	101.03	160
M2	1	558	01:45:00	74.4	1.9
M3	1	507	00:38:58	97.45	140
T1	1	556	00:57:54	89.69	36
T2	1	560	00:40:19	92.72	50
T3	1	548	00:27:27	99.28	150
T4	1	554	00:39:23	103.18	550
B1	1	516	00:18:12	92.25	20
B1	2	516	00:20:28	90	14
B2	1	560	00:20:51	92.35	24
B2	2	560	00:23:18	94.25	41
B3	1	530	00:31:40	87.5	12

Table 2 shows responses from Session Forms that indicate activity during outlying sessions for daily dose measurements.

Table 2

Session Form Responses for Activity during Outlying Sessions for Daily Dose Measurements

Participant	**Session**	**Dose (%)**	**Duration (HH:MM:SS)**	**Activity**
M1	1	540	00:26:02	Vocalises, Score study
T4	1	550	00:39:23	Recital run (1st half)
M2	1	1.9	01:45:00	Practiced by playing part on piano (1 hr), texted/practiced intermittently (30 mins), texted (30 mins)
B1	2	14	00:20:28	Repertoire
B3	1	12	00:31:40	Warm-up (5 mins), listening/light singing (5 mins), repertoire (15 mins), listening/light singing (3 mins), repertoire (5 mins)

Three participants also wore dosimeters for 16 hours of activity to simulate a full day of noise exposure. Table 3 shows the L_{EQ} and dose data for those days.

Table 3

L_{EQ} and Daily Dose Percentage for Three Full Days

Participant	**Session**	**Duration (HH:MM:SS)**	**L_{EQ} (dB)**	**Dose (%)**
S2	Day	16:00:00	95.97	2500
M1	Day	16:00:00	90.96	790
B2	Day	16:00:00	84.33	170

All three participants exceeded the recommended daily dose in a 16-hour period. During each of these days, participants also practiced in a practice room. In all three cases, the practice room session indicated the highest L_{EQ} levels of the entire day. Figures 1-3 indicate these peaks through graphical representation of L_{EQ} and dose levels for each participant.

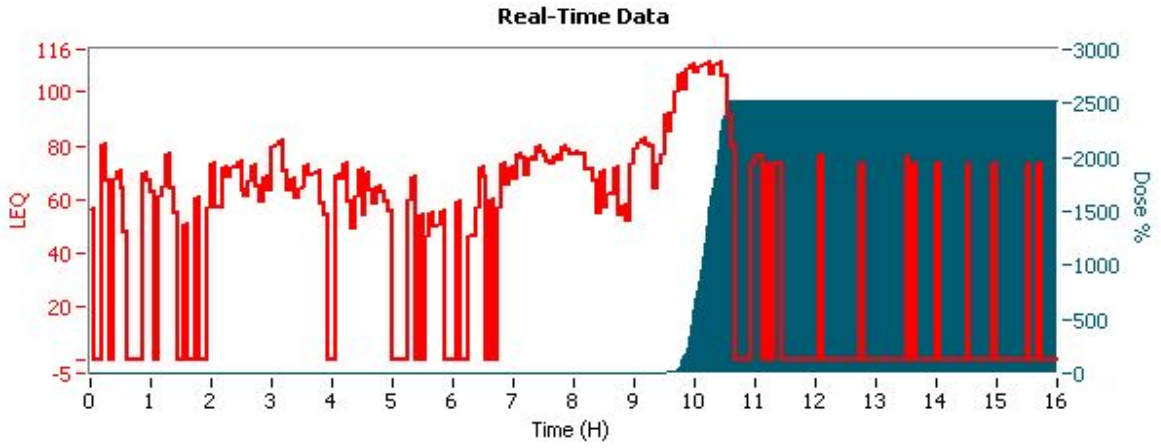

Figure 1. L_{EQ} and dose for S2 (practice room session around hour 10).

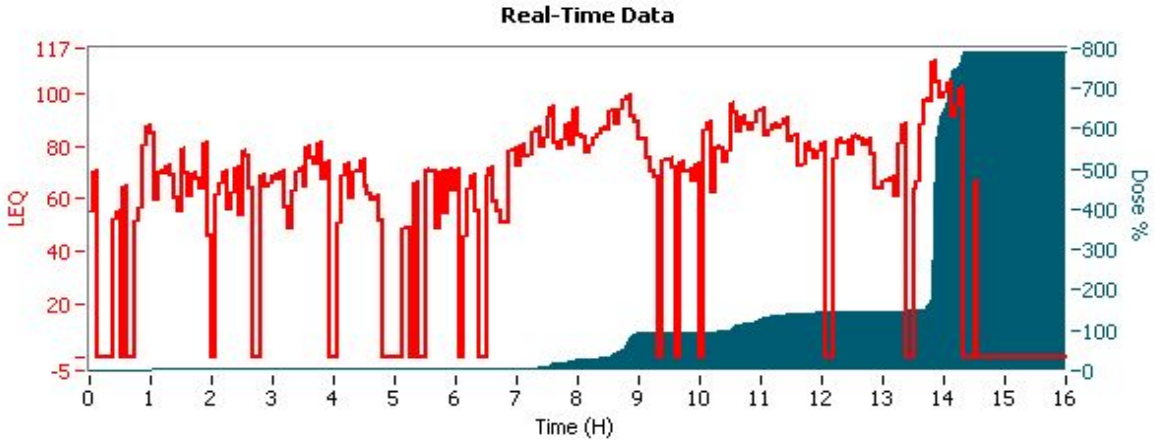

Figure 2. L_{EQ} and dose for M1 (practice room session around hour 14).

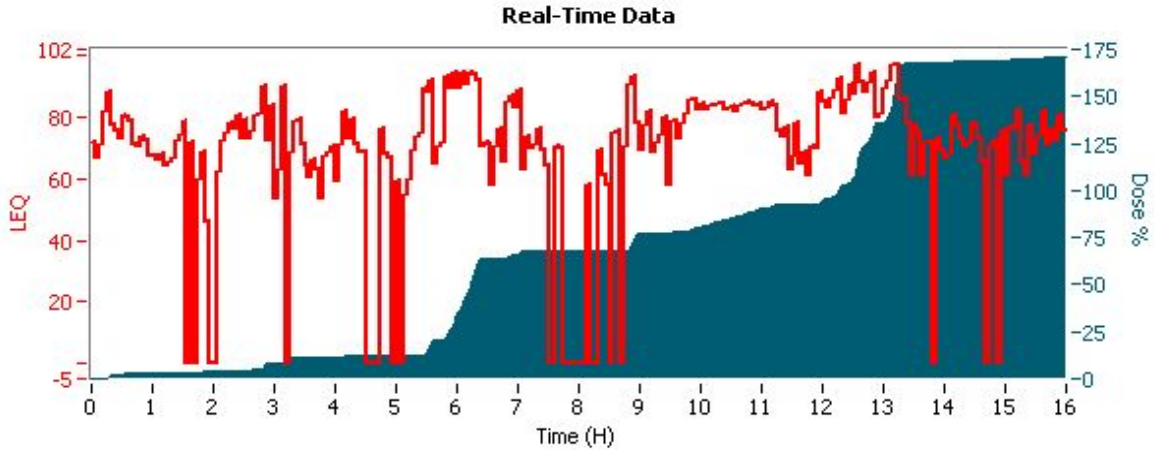

Figure 3. L_{EQ} and dose for M1 (practice room session around hour 13).

Research Question 2

The second research question asked if perception data indicated an awareness of noise levels and potential risk of hearing loss by university singers practicing in university-designated practice rooms. Table 4 shows responses to 5-point questionnaire items averaged across sessions for each participant, ranging from 1 (not at all) to 5 (all the time/completely).

Table 4

Averaged Questionnaire Responses for Each Participant

Question	**S1**	**S2**	**S3**	**S4**	**M1**	**M2**	**M3**	**T1**	**T2**	**T3**	**T4**	**B1**	**B2**	**B3**
1. I feel like the sound levels in my practice room exceeded safe levels.	4	1.5	2	2	1	5	3	3	4	2	5	2	1	1
2. I feel like the sound levels in my practice room affected my hearing, but only temporarily.	1	2	1	1	2	1	2	3	4	1	4	1	2	1
3. I feel like the sound levels in my practice room affected my hearing permanently.	1	1	1	1	1	1	1	1	2	1	3	1	1	1
4. I had to make adjustments to my practice routine or my vocal technique as a result of the sound levels in practice rooms when I sing in them.	1	1	1	1	1	1	3	4	1	4	1	1	3	1

5. I am made aware of policies my school implements to make music students aware of noise-induced hearing loss	1	1	1	1	1	1	1	1	1	2	1	3	1	1
6. I am warned about the risk factors associated with noise-induced hearing loss by my individual voice teacher.	1	1	1	1	1	2	3	1	1	2	1	1	1	3
7. I am warned about the risk factors associated with noise-induced hearing loss by my ensemble instructors.	1	1	1	1	1	2	2	1	1	2	1	1	1	1
8. I am warned about the risk factors associated with noise-induced hearing loss by other faculty.	1	1	1	1	1	2	1	1	3	2	1	2	4	1
9. I have concerns about my own hearing when I am practicing in practice rooms and/or performing.	1	2	2	1	1	2	3	3	3	1	5	1	3	5
10. I have concerns about my own hearing when I am going about my daily life.	3	1	1	1	1	3	2	3	2	1	5	1	2	5

11. I have experienced ringing in my ears after practicing in a practice room.	1	1	1	1	1	2	3	3	2	1	3	2	4	2
12. I have experienced ringing in my ears after an ensemble rehearsal.	1	1	2	1	2	3	2	4	1	1	4	1	2	1
13. I have experienced ringing in my ears after an activity not associated with my studies.	3	1	2	2	1.66	3	1	3	2	2	3	2	3	3
14. I use hearing protection when practicing in practice rooms.	1	1	1	1	1	1	2	1	1	1	1	1	1	1
15. I use hearing protection when rehearsing with ensembles.	1	1	1	1	1	1	2	1	1	1	1	1	1	1
16. I use hearing protection for activities not associated with my studies.	5	1	2	1	2	2	2	1	2	1	2	1	1	1

Discussion

The primary finding of this study is that the recorded L_{EQ} and percentage of daily dose experienced by singers in practice rooms is above the standards set out by NIOSH. Participants who experienced greater than 100% of the recommended daily noise dose frequently practiced for less than one hour. If we assume that the participants in this study are active in other musical activities throughout the day, including individual and ensemble rehearsal, we can assume that

the level of exposure will be far greater. Many participants who experienced less than 100% of the recommended daily noise dose could potentially still exceed this recommendation if they practiced more than once a day, or partook in ensemble rehearsal, considering that nearly all sessions lasted less than an hour (with the exception of one session where the participant was off-task for much of the time). Furthermore the data from participants who completed a full day of data collection indicated that all three exceeded the daily dose. The greatest peak of L_{EQ} in a day occurred in a practice room session, which indicated that noise exposure in practice rooms can potentially have a great effect on the overall daily dose experienced by participants.

Responses from the questionnaire data suggest that participants had mild concerns about levels in practice rooms and for their hearing health in general, but also indicated a general unawareness of the potentially lasting or permanent damage to their hearing. Almost no participants used hearing protection in practice rooms or in ensemble activities. With the dosimeter clearly indicating that the participants are experiencing noise levels that often exceed a daily dose limit in one practice session alone, it is clear that more must be done to promote awareness of hearing health and the lasting and permanent effects of high levels of noise exposure/NIHL, and to encourage all musicians–not just instrumentalists–to wear hearing protection.

The data from this study also indicate that the practice rooms available to the participants may not be of ideal properties to allow for safe practice. The rooms may be surveyed for the potential to improve the absorption of the wall materials, or curtains/portable absorption materials could be installed to reduce reflective sound waves. Alternatively, participants could opt to practice in a larger room if one was made available to them. Future studies might measure the sound levels of singers practicing in a larger room.

The data from this study are indicators of an increasingly documented hazard for musicians; however, more data is required to strengthen the findings of this study. Future research might include a greater number of participants in order to further explore the materials in this study.

NIHL is a potentially terrifying prospect for many professional musicians, and it is an affliction that can have a hugely negative impact on someone's career and livelihood. It is also permanent biological damage and cannot yet be restored technologically. It is, therefore, paramount for music educators to provide safe environments for their students to practice in, to promote hearing health and conservation, and to provide students with hearing protection and other materials to facilitate their efforts in preventing NIHL.

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