NOISE EXPOSURE AND HEARING LOSS AMONGST CLASSICAL MUSIC STUDENTS

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1 INTRODUCTION

The Control of Noise At Work Regulations 2005 came into force in April 2006 [1]. The new piece of legislation covers all types of noise, as for instance building work and machinery in the workplace. Control measures are necessary if noise levels are excessive. The entertainment sector was given an exemption from the regulations until April 2008 and this includes workplaces where live music or recorded music is being played e.g. restaurants, bars, auditoria, or nightclubs.

The project was divided into two different parts. The first part consisted of Noise Risk Management Strategy undertaken at Royal Academy of Music. The Academy set out a monitoring plan to measure the daily noise exposure level of students throughout a working day based on diaries kept by the students. This included a preliminary risk assessment of 49 instruments and voices, thus identifying the noisiest instruments. The second part consisted of health surveillance for all 300 first year students, the aim being to identify those with the greatest hearing losses.

2 RISK ASSESSMENT

Risk assessment must be carried out if any employee is likely to be exposed to noise above the lower exposure action values. The daily noise exposure depends on the noise level and the duration of sound. The assessment enables the employer to quantify the noise exposure risk, which can then be prevented or controlled.

The first part of the study consisted of an individual noise survey for each of the 49 instruments and voices of students and it was further divided into two phases. The measurements of the first phase were taken in different rooms. The second phase on the contrary, was undertaken in the same room, where instrument size allowed. The worst of the two noise exposure values was used.

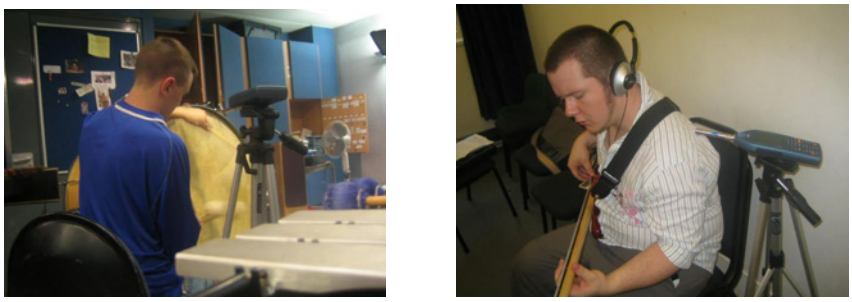

Figure 1. Sound level monitoring at ear level (Royal Academy of Music)

Measurements were taken using a Norsonic Nor132 sound level meter at approximate ear level, see Figure 1. The parameters measured were L_{Aeq} over a reference time interval (musical piece duration) and L_{peak}. No L_{peak} measurement was above the lower exposure action value, where as 37 instruments were above the L_{Aeq} upper exposure action value, see Figure 2.

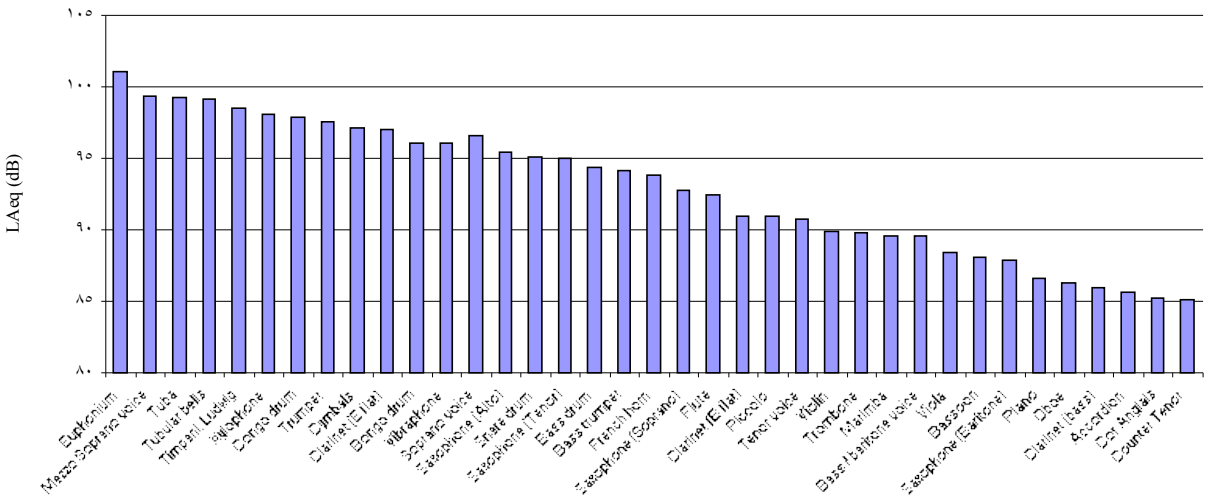

Figure 2. Instruments producing excessive sound levels measured at ear level in practice rooms.

The second part of the project consisted of assessing the musicians' diaries to evaluate their noise exposure during typical activities. Various assumptions were necessary for the effective playing time to be calculated. The students' diaries were assessed activity-by-activity in order to obtain a daily personal noise exposure dosage based on the Health and Safety Executive (HSE) guidelines using a "% points" system for each activity [1]. The students provided the following information: music piece performed, rehearsed or practiced, number of people/instruments playing and the room used. Thus it was representative of typical practice or teaching for a particular instrument or voice.

The project covered 49 principal instruments, only 20 were unfortunately returned by the students: 6 brass, 4 string, 3 woodwind, 3 keyboard players, 2 singers, 1 percussionist and 1 accordionist. The calculated noise exposure dose values were above the proposed legal limits in most cases. Therefore, it has been initially recommended that the Academy must follow a noise risk mitigation strategy [2].

Hearing protection is the only mitigation measure required for some activities where the calculated noise exposure level was above the limit; 85 dB(A) for 8 hours corresponds to daily dose received of 100 %. If the musicians wear the hearing protection suggested while they are practicing for some activities (Ultratech Hifi, SNR=21, real value=17 dB), the daily dose received would be significantly reduced. Another earplug, ER-15, offers 15 dB (real value=11 dB) of noise reduction; these allow the musicians to hear more clearly especially in cases where they are playing within an orchestra. The real value is lower than the given Single Number Reduction (SNR) due to the necessity of having a flat response for musicians' earplugs, where as traditional earplugs have much higher performance at higher frequencies.

Based on the noise survey, the available diaries and the assumption given above, Figure 3 shows the noise dosage of 20 principal instruments.

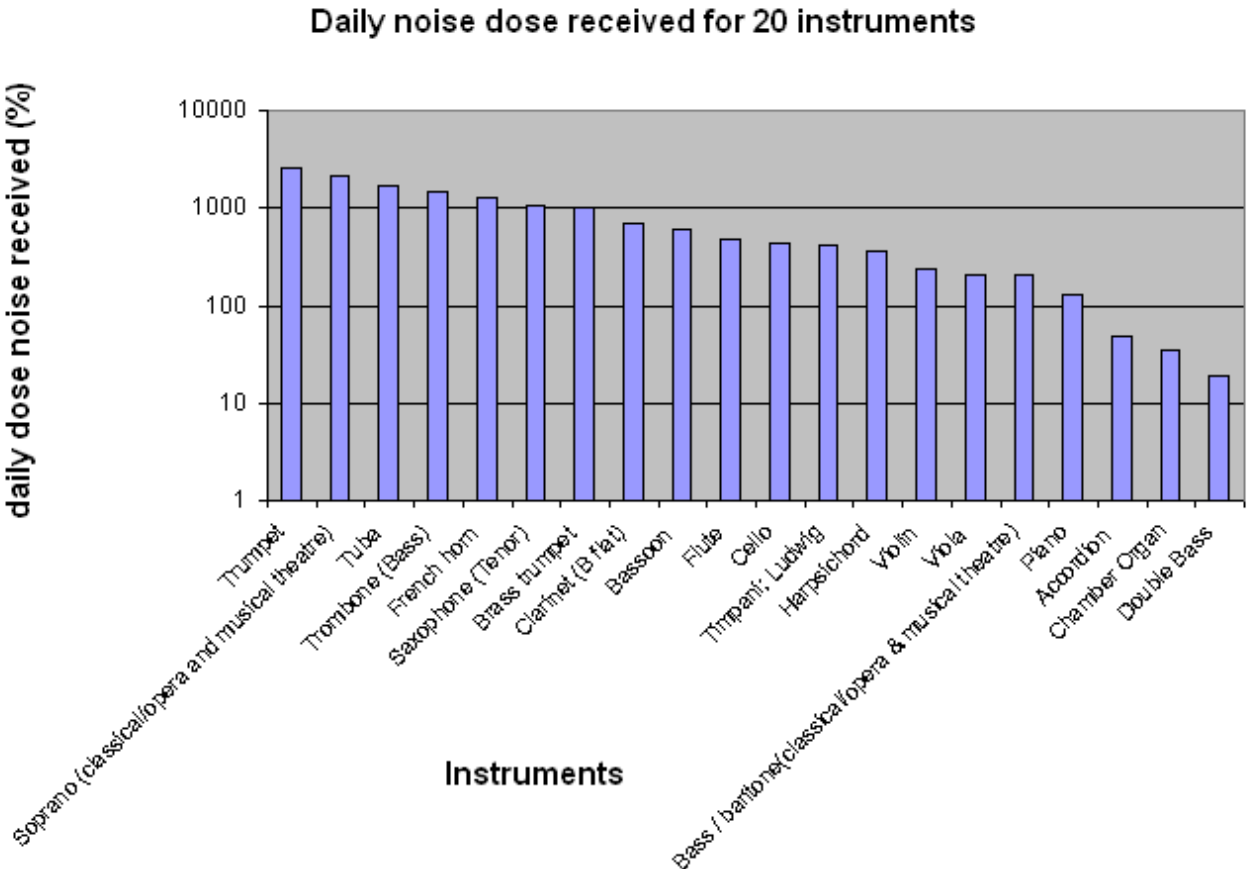

Figure 3 Ranked instruments based on noise dose for a typical day (Survey/Diary)

The daily dose received results were as expected [3]; the highest values were found for the brass section (trombone, jazz trumpet, tuba, French horn and bass trumpet) which corresponded with the highest average noise levels from our survey, see Figure 2, and will have to wear protection during certain noisy activities. On the other hand, the strings and keyboard group received the least noise dose (double bass, jazz piano, viola, violin, and harpsichord) and these musicians are less likely to be required to use hearing protection. Finally, in the case of the voice group, the noise reduction required will have to be found by other means, as ear plugs directly affect the performance of the singers.

3 HEALTH SURVEILLANCE OF MUSICIANS

Health surveillance is required by law for all employees at risk from high noise exposure. It was decided that all students would undergo an audiometric test in the first month of attending the Royal Academy of Music. A seminar was arranged during Freshers Week to inform the students of the dangers of excessive noise exposure and some precautionary measures that could be easily taken. A schedule was organized for tests to be undertaken at London South Bank University.

One-to-one interviews with each student were used to identify any factors which may influence the health surveillance results. The questionnaire concerned aural health, instruments played, hobbies, practicing hours etc. Each student underwent afterwards an automated audiometric screening test in an environmental chamber; see Figure 4. The test was based on a pure-tone air conduction Bekesy test.

Figure 4. Environmental chamber with double layer doors and Amplivox audiometric equipment.

The results were printed and discussed with each student. An Excel spreadsheet was developed to calculate the summed hearing loss according to the hearing categories given in Appendix F of the Control of Noise at Work Act 2005 [1]. Three colours were used as illustrative of the three hearing categories for each ear: a green number meaning acceptable hearing ability (normal levels of loss for the relevant population), amber number- mild hearing impairment (warning levels 20% of relevant population) and red- poor hearing (referral levels 5% of relevant population). Hard copies of the audiograms were given to the students and the Royal Academy of Music. The spreadsheet was also designed to identify and highlight significant hearing differences between left and right ears and any rapid hearing loss when the students' return for follow up tests.

Figure 5 indicates that the brass group has approximately 3.3 dB higher average sum hearing loss for the right ear than the left ear. This difference may be a consequence of asymmetric instruments, such as the French horn where the bell is adjacent to the right ear. For woodwind, the right ear had an average 2.8 dB additional hearing loss; similarly this could be attributed to asymmetric instruments such as the flute/piccolo. However, others groups were not so easily matched. In many cases, there was a significant difference of hearing loss between both ears even if the instruments were symmetric indicating the existence of other factors that may have influenced those musicians hearing condition [4].

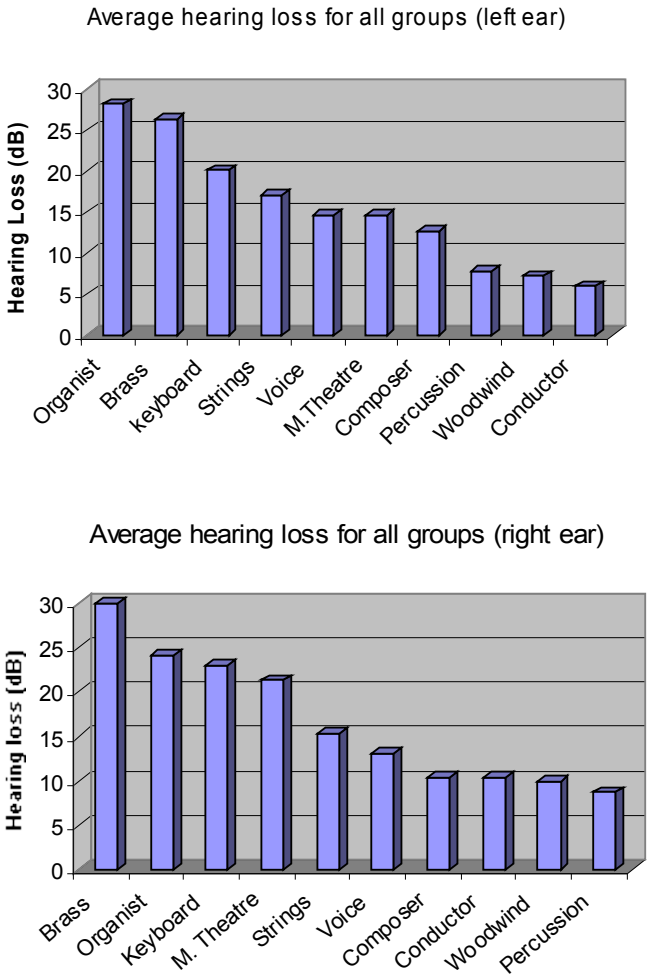

Figure 5. Average hearing loss (summed 1-6kHz losses) for all instrument groups.

Table 1 below shows the percentage of students in each hearing category (acceptable, warning and referral) for all groups of instruments and voices. The worst case was that of the brass group, whilst the best was that of the woodwinds, despite having noise levels measured during the survey of between 87-97 dBA. The percussionists were amongst the noisiest groups, but have an excellent record according to the health surveillance categories. However, only six percussionists were tested. Thus, this particular data was not statistically reliable.

	LEFT EAR			RIGHT EAR		
	Acceptable	Warning	Referral	Acceptable	Warning	Referral
Brass (19)	94.7	5.2	0.0	79.0	10.5	10.5
Keyboard(52)	96.0	2.0	2.0	90.5	9.6	0.0
Musical Theatre (18)	89.0	5.5	5.5	95.5	5.5	0.0
Strings (95)	92.7	6.3	1.0	92.8	5.2	2.1
Voice (60)	96.6	3.4	0.0	95.0	5.0	0.0
Woodwind (36)	100.0	0.0	0.0	97.2	2.7	0.0
Percussion (6)	100.0	0.0	0.0	100.0	0.0	0.0

Table 1. Hearing categories for each instrument group

It should be noted that the musicians had significantly better hearing than the general population as warning and referral levels correspond to 20% and 5% of the population.

The student population was approximately 2/3 female, 1/3 male, with an age distribution given in Figure 6. Figures 7 and 8 show the break down for women's right and left ears in terms of hearing category. It can be seen that the warning levels are doubled for the female left ear for the 25-29 year age group. This can be explained by the tendency of stringed instruments to be played by females, 95%, and that hearing losses take time to surface. Considering the men, no such tendency was seen. However, the incidence of males in the warning category is twice that of the females. Referrals are consistently higher for both men and women for the older age group than the younger.

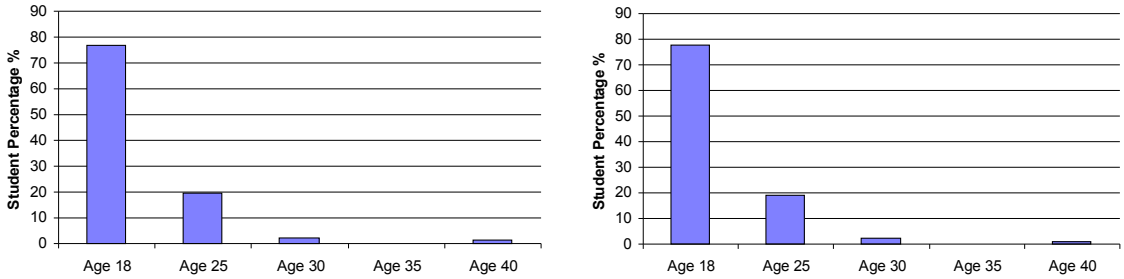

Figure 6. Male and Female age distribution for 1st Year students at the Royal Academy of Music.

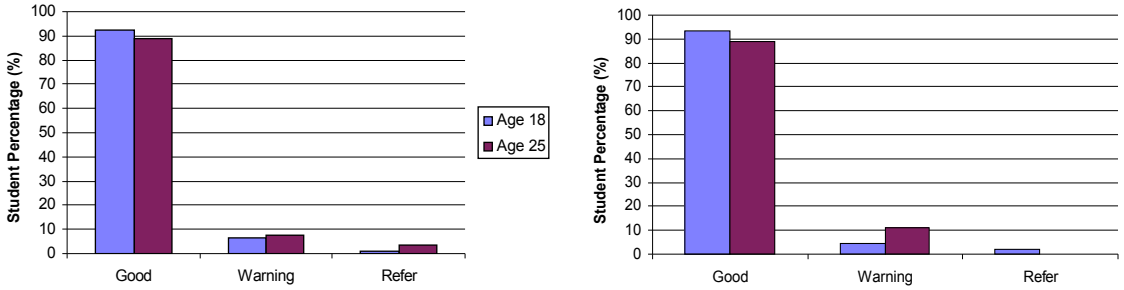

Figure 7. Female hearing loss categories for the primary age groups.

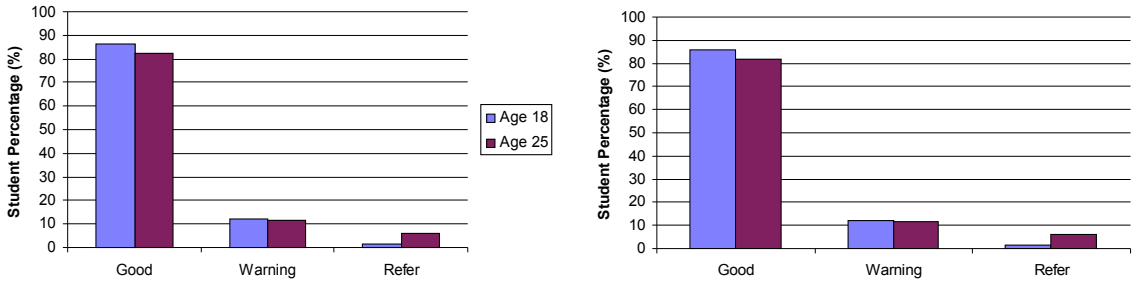

Figure 8. Male hearing loss categories for the primary age groups.

4 CONCLUSION

It was found that brass, woodwind and percussion groups were exposed to the highest noise levels and daily noise dose. For these practitioners the noise exposure was above the prescribed values. Strings and keyboard players were exposed to lower noise levels and consequently had lower typical daily noise doses. It should be noted that musicians spend many hours practicing alone each day.

The health surveillance results show that brass is the group with, on average, the most hearing loss; correspondingly brass is also the noisiest group. Analysis of the audiograms shows that overall the musicians hearing is better than that of the general population for the same age. Men

have a higher incidence of warning levels of hearings loss than women; 12% compared to 6%. Older female students had an increased incidence of warning levels of hearing loss.

It was noted in the questionnaires that many students use an iPod on a daily basis. It has been found that iPods using the standard in-ear earphone should not be used whilst traveling on London Underground trains due to the high noise level, 84 dBA. This results in the user masking the train noise, hence in-ear noise levels were found to rise to 93 dBA on average [5].

5 FUTURE WORK

Dosimetry will be used in the next stage of the project. A wide range of musicians will carry a dose badge over the course of a typical day, in particular those identified as at risk, based on the activity diary information and detailed diaries will be kept. The resulting data will be compared to the noise exposure dose calculated from the noise survey / activity diary to determine the reliability of the method as an estimate of noise dose. Audiometric data will be reanalysed to detect early signs of hearing loss amongst the musicians.

It is proposed that relying on Personal Protective Equipment (PPE) solely is not an acceptable solution and therefore other potential solutions should be investigated:

1. Education of the Youth Orchestra.
2. Room labeling to indicate max practicing duration for various types of instrument.
3. Spatial separation of the musicians either through larger room size or different amount of musicians allowed in the room [6].
4. Isolating noisy instruments by localized use of sound-absorbent materials.
5. Reducing the number of performances from 600 to 550 per year.
6. Rescheduling and balancing the music repertoire practiced / performed based on the noise levels that those music pieces can produce.

6 REFERENCES

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