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A LONGITUDINAL STUDY OF HEARING LOSS AMONGST CLASSICAL MUSICIANS

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1 INTRODUCTION

With the introduction of the new Control of Noise and Vibration regulations [1], health surveillance is necessary for any employee at risk of high noise exposure. As such, classical music teachers/students from April 2008 must be assessed. The Royal Academy of Music (RAM) decided that all 1st year students must undergo tests as part of their induction during Freshers' week. This work is just part of that undertaken, over the last 3 years, with RAM. A Noise Risk Management Strategy was undertaken[2] dosimetry was performed and novel solutions were proposed to control the noise[3].

2 AUDIOMETRIC TESTING PROCEDURE

Prior to the audiometric testing, seminars were arranged each year during Freshers' Week to inform the students of the dangers of excessive noise exposure and some precautionary measures that could be easily taken. Presentation material for the seminars given was different depending on the instrument group attending and was focusing on the existing literature and noise exposure dangers associated with each instrument. A schedule was organized each year 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, written using SPSS, concerned aural health, instruments played, hobbies, practising hours etc. Each student then undergoes a automated audiometric screening test in a sound proof booth, see Figure 1. The test used a pure-tone air conduction Bekesy test using TDH 49 headsets. In September 2009, an additional audiometer and booth were commissioned to expedite the testing.

Equipment used: Amplivox CA850-1 microprocessor audiometer (2007-2010)
Amplivox CA850-4 microprocessor audiometer (2009-2010)
Headphones TDH39 (2007-9) THP49 (2009-10)

Figure 1 Environmental chamber with double layer doors and Amplivox audiometric equipment

During academic years 2007-2009 testing, student's hearing loss was assessed for frequencies between 500 Hz and 6000 Hz, as required by the Control of Noise at Work Regulations. For research purposes, in order to identify a possible dip at 6000 Hz (i.e., increased hearing loss) believed to be representative of noise induced hearing loss, the 8000 Hz frequency was added to the testing procedure (2009-2010 testing). After the testing was completed, 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. 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 to 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.

3 AUDIOMETRIC TESTING RESULTS

Audiometric testing during three consecutive years resulted to a database of almost 1000 students, currently the largest existing audiometric database for musicians. Results over the three years indicated that the majority of the students had good hearing on both ears (94% of the students had good hearing on the left ear and 93% of students on the right ear), see tables 1, 2 and figures 2, 3.

			Test Year			
			2007	2008	2009	Total
Left Ear H&S Hearing Level	**Good**	Count	319	294	293	906
		% within Left Ear H&S Hearing Level	35.2%	32.5%	32.3%	100.0%
		% within Test Year	91.7%	97.0%	93.0%	93.8%
	Warning	Count	22	8	16	46
		% within Left Ear H&S Hearing Level	47.8%	17.4%	34.8%	100.0%
		% within Test Year	6.3%	2.6%	5.1%	4.8%
	Referral	Count	6	1	5	12
		% within Left Ear H&S Hearing Level	50.0%	8.3%	41.7%	100.0%
		% within Test Year	1.7%	.3%	1.6%	1.2%
	Deaf	Count	1	0	1	2
		% within Left Ear H&S Hearing Level	50.0%	.0%	50.0%	100.0%
		% within Test Year	.3%	.0%	.3%	.2%
Total		Count	348	303	315	966
		% within Left Ear H&S Hearing Level	36.0%	31.4%	32.6%	100.0%
		% within Test Year	100.0%	100.0%	100.0%	100.0%

Table 1 Left Ear H&S Hearing Level vs Test Year

			Test Year			
			2007	2008	2009	Total
Right Ear H&S Hearing Level	**Good**	Count	309	289	296	894
		% within Right Ear H&S Hearing Level	34.6%	32.3%	33.1%	100.0%
		% within Test Year	88.8%	95.4%	94.0%	92.5%
	Warning	Count	31	7	11	49
		% within Right Ear H&S Hearing Level	63.3%	14.3%	22.4%	100.0%
		% within Test Year	8.9%	2.3%	3.5%	5.1%
	Referral	Count	8	7	7	22
		% within Right Ear H&S Hearing Level	36.4%	31.8%	31.8%	100.0%
		% within Test Year	2.3%	2.3%	2.2%	2.3%
	Deaf	Count	0	0	1	1
		% within Right Ear H&S Hearing Level	.0%	.0%	100.0%	100.0%
		% within Test Year	.0%	.0%	.3%	.1%
Total		Count	348	303	315	966
		% within Right Ear H&S Hearing Level	36.0%	31.4%	32.6%	100.0%
		% within Test Year	100.0%	100.0%	100.0%	100.0%

Table 2 Right Ear H&S Hearing Level vs Test Year

Percentage of good hearing at both ears was highest during 2008-2009 year, however as the results were found to be very close, this is considered a random event. Out of 966 students over the 3 years, only 1.2% had referral levels in the left ear and 2.3% in the right ear. Additionally, only 4.8% had warning levels in the left ear and 5.1% in the right ear. These percentages are far below the 5% and 20% of the general population given by the HSE categorization scheme[1] for referral and warning levels respectively. Thus the musicians' hearing was found to be significantly better than that of the general population.

The results were reanalysed by ear for each instrument group, such as wind, brass, percussion, keyboard, voice. The brass group had a summed hearing loss (1,2,3,4 and 6kHz) approximately 3.3 dB higher on average for the right ear than the left ear, see Figure 2. 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 in hearing acuity between ears even if the instruments were symmetric indicating the existence of other factors that may have influenced those musicians hearing condition [4].

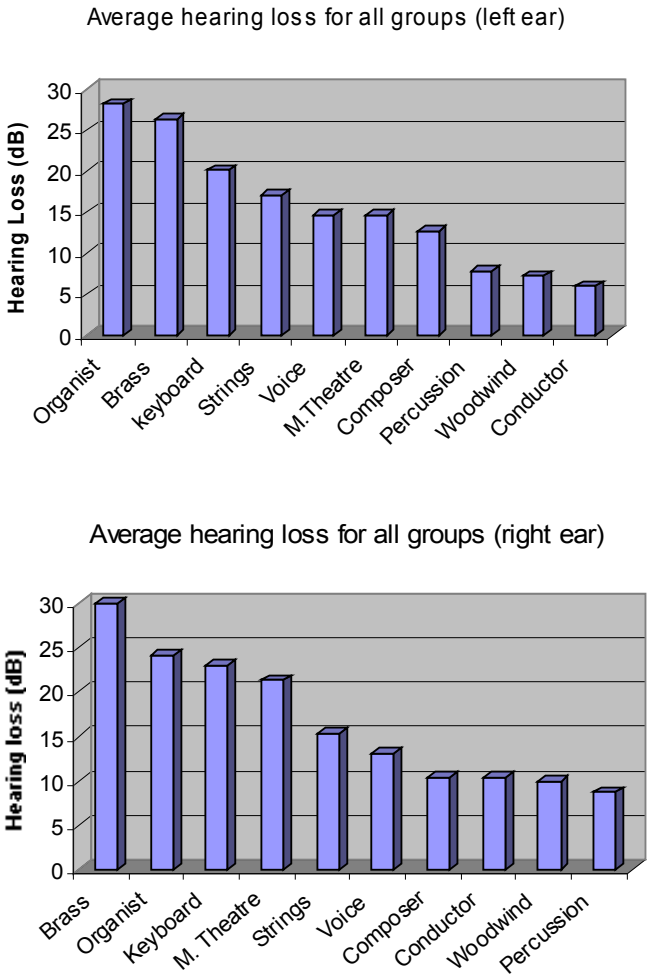


Figure 2. Average hearing loss (summed 1-6kHz losses) for all instrument groups.

The data was further analysed into instrument group hearing categories for groups of 20 or more individuals, see Table 3. The worst case was that of the brass group, with a 12% incidence of warning levels of hearing loss. The musical theatre group had the best hearing, in terms of hearing categorization with 2.5 % incidence of warning levels of hearing loss.

	LEFT EAR			RIGHT EAR		
	Acceptable	Warning	Referral	Acceptable	Warning	Referral
Piano (165)	96.2	3.0	0.6	94.5	4.2	1.2
Strings (250)	92.4	4.8	0.4	93.6	4.8	1.6
Woodwind (88)	96.6	3.4	0.0	96.6	4.5	2.3
Brass (77)	87	11.7	1.3	81.8	13.0	5.2
Voice (133)	94.7	3.8	0.8	93.2	3.8	2.3
Musical Theatre (98)	96.9	2.0	1.0	96.9	3.1	0.0
Percussion/Timpani(22)	86.4	9.1	4.5	95.5	4.5	0.0
Opera (26)	96.2	3.8	0.0	96.2	0.0	3.8

Table 3. Hearing categories for each instrument group

The student population was approximately 2/3 female, 1/3 male, with an age distribution of 18-29 years old [2]. The data can be reanalysed by gender in terms of hearing category. It can be seen that

the warning levels are greater, in terms of percentages for men, than for women. Although overall the right ear has a higher incidence of referral levels of hearing loss than the left, see Figure 4.

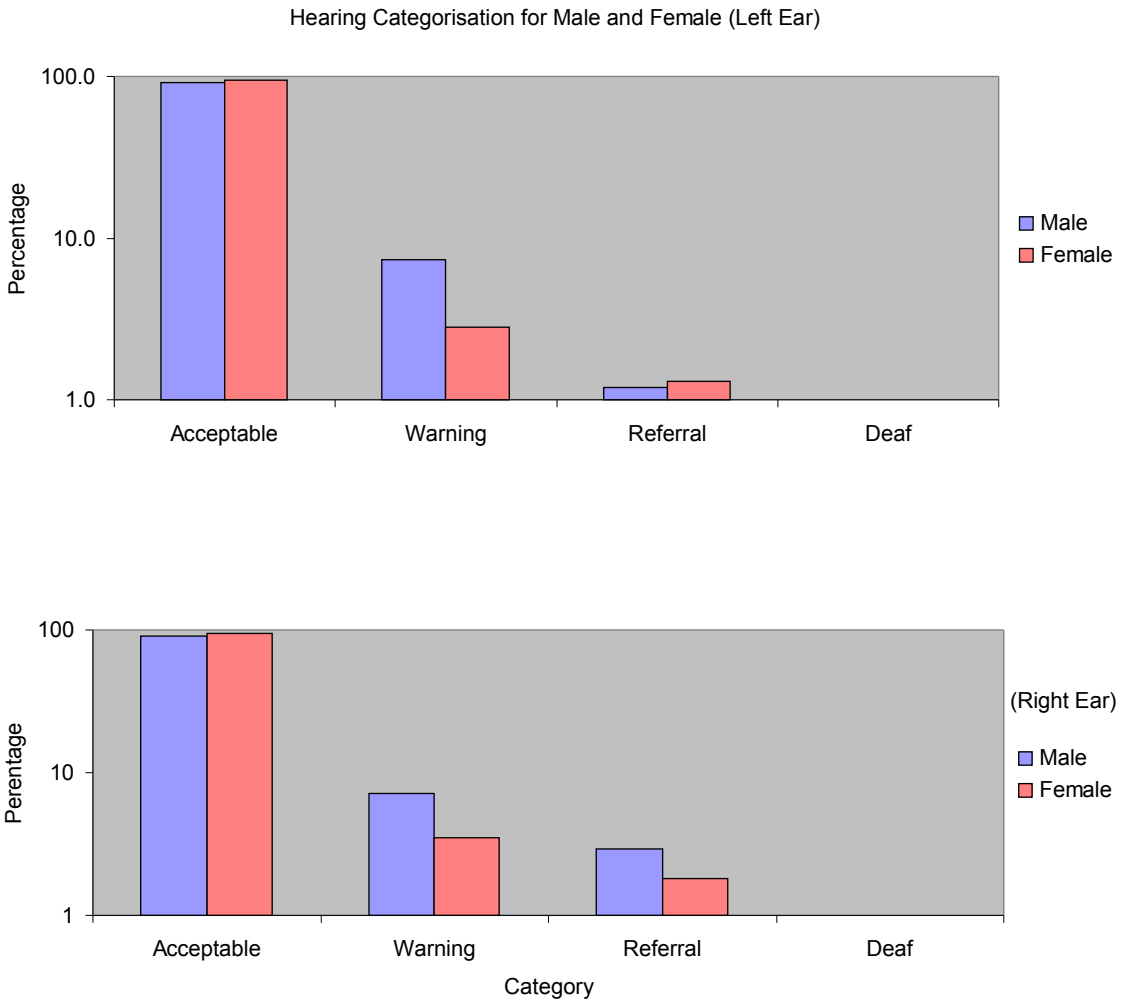
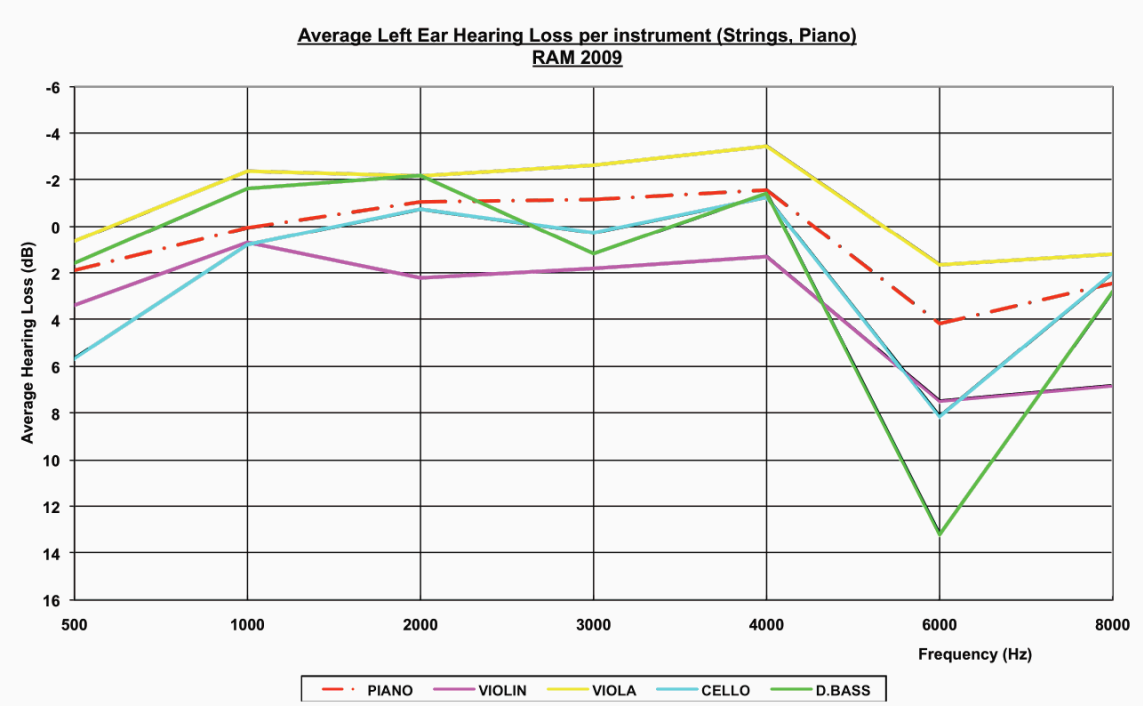


Figure 3. Distribution of hearing loss by categorization for men and women for the left and right ear

Additional information was collected from September 2009, by including the 8 kHz frequency in the audiometric screening. This information could then be used to determine if 'music' induced hearing loss occurred at 6 kHz, by inspecting if a well defined notch occurred at this frequency, rather than the normal 4 kHz notch typically found in cases of 'noise' induced hearing loss. The data was reanalysed for instrument groups by ear, see Figure 4-6.

The right ear has more pronounced 'music' induced hearing loss, particularly for double bass and cello for both ears. For the right ear only the viola player had a distinct dip in their hearing at 6 kHz, see Figure 4. For the woodwind the clarinet players appear to have 'music' induced hearing loss, as does the bassoonists, but only in the right ear, see Figure 5. For the brass group, all the players appear to suffer mild 'music' induced hearing loss in the left ear, see Figure 6. The left ear of the tuba players has early stages of hearing loss at significant levels.



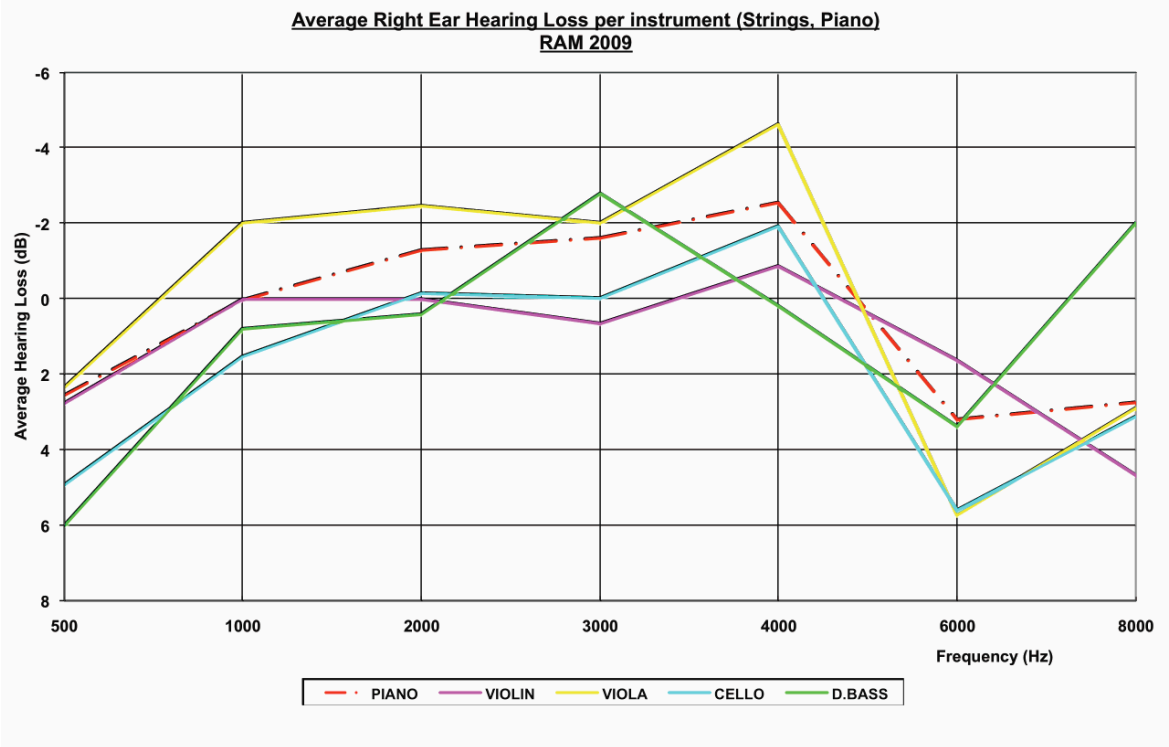


Figure 4. Averaged audiograms for strings and piano (2009 music students)

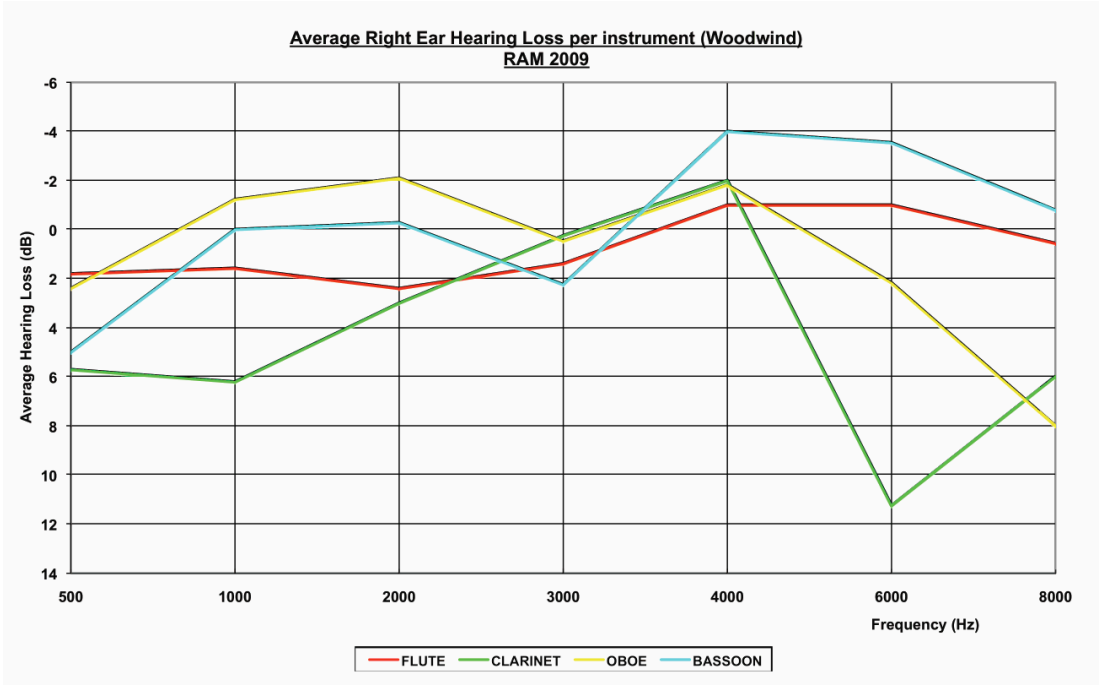


Figure 5. Averaged audiograms for woodwind (2009 music students)

Figure 6. Averaged audiograms for the brass (2009 music students)

4 CONCLUSION

It was found that 95% of the 966 music students had acceptable levels of hearing loss according to the hearing categories outlined in the Control of Noise at Work Regulation appendix. Over the three years, there is minor variation in the character of the audiograms for the instrument groups, but

consistently the girls have better hearing than the boys. The brass group have the highest incidence of warning levels of hearing loss.

For the 2009 music students an additional frequency was tested, 8 kHz, this allowed a 'music' notch in the audiograms to be clearly seen, particularly for the brass. It is suggested that for music, as produced solely by a musician, health surveillance audiograms should include the 8 kHz frequency. Of course over time the 6 kHz notch will disappear into the age related hearing loss, but for students there is a clear advantage in testing for early signs of hearing loss.

5 FUTURE WORK

Wide spread dosimetry will be used in the next stage of the project using a new specially designed dose badge from Audio 3, the Soun**dB**adge. This will allow a much wider range of musicians to be measured over the course of a typical day, thus eliminating the need for sampling. The resulting data will be compared to the audiometric results to quantify the potential future effect on the students' hearing.

The next stage in the audiometry will commence on the 12th April 2010 when the first cohort of students completing their three years of study, 164 students have been identified. In the future all students studying more than 24 calendar months at the Royal Academy of Music will be retested and the audiometric data compared to their original audiograms, thus allowing any rapid signs of hearing loss to be detected.

6 REFERENCES

1. Health and Safety Commission (2005). *The control of Noise at work, Regulation 2005.* 2nd Edition. HSE Books.
2. S. Morant, Noise Risk Management Strategy at Royal Academy Music and Health Survey issues, MSc Thesis, London South Bank University, 2007.
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4. P. Wash. Investigation into the noise levels produced by personal MP3 players, MSc Thesis, London South Bank University, 2007.