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## **Noise exposure of students on degree courses related to popular music**

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### **ABSTRACT**

In recent years, the number of students studying degree courses based around the popular music industry have increased sharply<sup>1</sup>. These students are regularly involved in rehearsal and recording with electronically amplified sound, in addition to the normal noise exposure to which students commonly subjects themselves. The combination of the normal noise exposure of young people and regular involvement amplified sound suggests a higher than average noise exposure risk for these students. To date the majority of noise studies on students have focused on Ipod exposure (such as Portnuff and Fligor<sup>2</sup>), and classical, orchestral and marching band musicians.

A pilot study was run with 26 students on degree courses related to the popular music industry, from both production and performance. Students were surveyed regarding their musical habits both within and external to their university courses. This was then followed by a larger study of 100 students, including questionnaires, Noise Dosimetry of studios/recording spaces and personal noise dosimetry of a sample of students. Results indicated that students were at a high risk of excessive noise exposure from both social and university music activities. Students, despite 80% reporting having received education on hearing loss, were unlikely to wear hearing protection when in a loud music environment. 83% of the pilot study reported having suffered from tinnitus after being in a music recording, rehearsal or concert, 50% reported threshold shift and 28% reported having experienced pain or discomfort. This suggests the need for more robust education and monitoring programmes on popular music courses.

### **1. INTRODUCTION**

Noise is a health risk, with the associated result of excessive noise exposure being Noise Induced Hearing Loss (NIHL). The effects of noise induced hearing loss are well documented (e.g. by Smith and Evans<sup>3</sup>), generally resulting in a reduction of overall hearing threshold, with increased loss at high frequencies. In particular, Borchgrevink<sup>4</sup> reports that NIHL generally leads to an audiometric 'notch' between 4-6kHz in which the hearing threshold is disproportionately reduced. Although there is still some debate about the levels and types of

noise which most contribute to NIHL<sup>5</sup>, it is generally accepted that peak noises of 140 dB or higher can cause immediate acoustic trauma, and that long term exposure to sound pressure levels of over 80 dB pose a risk of long term damage to the hearing system<sup>5</sup>. The use of amplified music in particular has regularly been identified as a cause for potential concern.

Noise exposure of young people is of increasing interest to the health and education communities, with studies reporting noise induced hearing loss in children and young people due to high levels of noise exposure from a variety of sources (e.g. Ising et al<sup>6</sup>). Several studies have identified hearing loss and potential noise risks of a variety of leisure activities amongst different groups of young people, in particular those regularly listening to loud music. 12.5% of US young people aged 6-19 years show an audiometric notch in one or both ears<sup>7</sup>.

The majority of noise studies on young people have focused on the effects of personal music players such as the Ipad, or of social behaviours such as attending concerts, nightclubs and music bars. Other studies have concentrated on music performers, including marching bands in the USA and school/college orchestras. Studies have used interviews and questionnaires to assess self-reporting of behaviours, and have used standardised technologies to quantitatively monitor noise exposure and its effects (e.g. Peters et al<sup>8</sup>), including LAEQ monitoring and personal noise dosimetry as recommended by Health and Safety Executive guidelines<sup>9</sup> and pure tone Audiometry as specified by the British Society of Audiology<sup>10</sup>.

The music industry in the UK came under the noise at work regulations in April 2008<sup>11</sup>, with employers in the entertainment industry from orchestras to nightclubs legally required to adhere to the action levels for controlling noise exposure (ibid). In recent years, the number of students at school, Further and Higher Education levels studying educational courses based around the popular music industry has increased sharply<sup>1</sup>. These students are regularly involved in rehearsal and recording with electronically amplified sound, in addition to the normal noise exposure to which students commonly subjects themselves. As they are not employees, these students are not subject to the same legal requirements which are applied to the commercial music industry, yet the combination of the 'normal' noise exposure associated with leisure activities of young people and regular use of amplified sound in their studies suggests a higher than average noise exposure risk for these students. Noise studies on young people have largely focused on Ipad exposure<sup>2</sup> classical, orchestral and marching band musicians (e.g. Miller<sup>12</sup>) and students working in university venues. Several of these studies have found that students involved in music based courses and events exceed recommendations for safe listening levels, although there is still a lack of data on student musicians generally. There have been few if any studies focusing on students specialising in popular music, and it is suggested that students specialising in popular music are potentially at a significantly heightened risk even when compared to musicians studying in other musical genres, due to the impact of regularly using amplification for their music performance and rehearsal.

## **2. METHODS**

A sample of Students on a variety of Higher Education (Bachelors Degree, Foundation Degree or Higher National Diploma) popular music courses were studied for academic and leisure time exposure to noise. An initial pilot group of 26 students on 3 different HE courses were surveyed using a short 10 question survey to examine self-reported durations and levels of exposure to music from study, leisure and employment.

From the pilot study, 88% reported having had at least one symptom associated with noise induced hearing loss (threshold shift, tinnitus or discomfort) while attending or performing at a music event. 80% of students reported having had education on hearing safety. Despite this, students were unlikely to regularly wear hearing protection when in a music environment, with only 24% reporting that they always or usually wore hearing protection when in a loud music environment (concert, recording or rehearsal).

These results suggested that students on courses related to popular music are likely to be at a high risk of noise induced hearing loss. In order to examine this further, the pilot study was followed by a more detailed survey completed by 100 students across a wide range of HE courses related to popular music, specialising in subjects such as Audio System Design, Popular Music Performance, Electronic Music and Music Recording/Production.

### **A. Participants**

100 students across levels 1-4 from 8 different undergraduate courses were surveyed. The age range was from 18 years to 64 years. Mean age was 22.6 years and median age 21 years.

The survey group had a significant gender imbalance, with 92 male subjects and only 8 female. This accurately represented the demographic across the courses surveyed.

### **B. Materials/Equipment**

A 30 question survey was used to examine self reported music based activities including: rehearsal/recording duration, subjective loudness of rehearsal/recording, genres of music played/recorded, amount of loudspeaker and headphone use in rehearsal/recording, attendance at live concerts and nightclubs, use of personal music players, home stereos and in car audio, education on noise and hearing loss, use of HPDs, instances of tinnitus, threshold shift and pain/discomfort, and any specific issues relating to hearing loss that the student felt relevant.

In addition to the survey a number of noise measurements were carried out. Five Cirrus Research Dosebadge™ noise dosimeters were used to record 1 minute average (A-weighted) and peak (C-weighted) noise exposure over time in recording studios and individual/group rehearsal rooms used by the students in the survey. Dosebadges were calibrated before each use, and were set to record when the sound level exceeded 70dBA. Data was then downloaded into a PC where Cirrus Research dBlink™ software was used to analyse noise levels and patterns of exposure and generate LA<sub>EQ</sub> measurements for particular events. In total, 8 rehearsal rooms (3 group and 5 individual) were recorded 3 times each throughout their opening hours, in addition to 8 recording studios and one 'mixing' space.

Further noise dose recordings were made using the Dosebadges at a number of key positions at live rock music events in two local music venues popular with the students. LA<sub>EQ</sub> data was created for a number of music sets in a live rock concert at each venue, with positions directly in front of the stage, in the middle of the audience, at the sound engineer's mixing position, and around the audience perimeter.

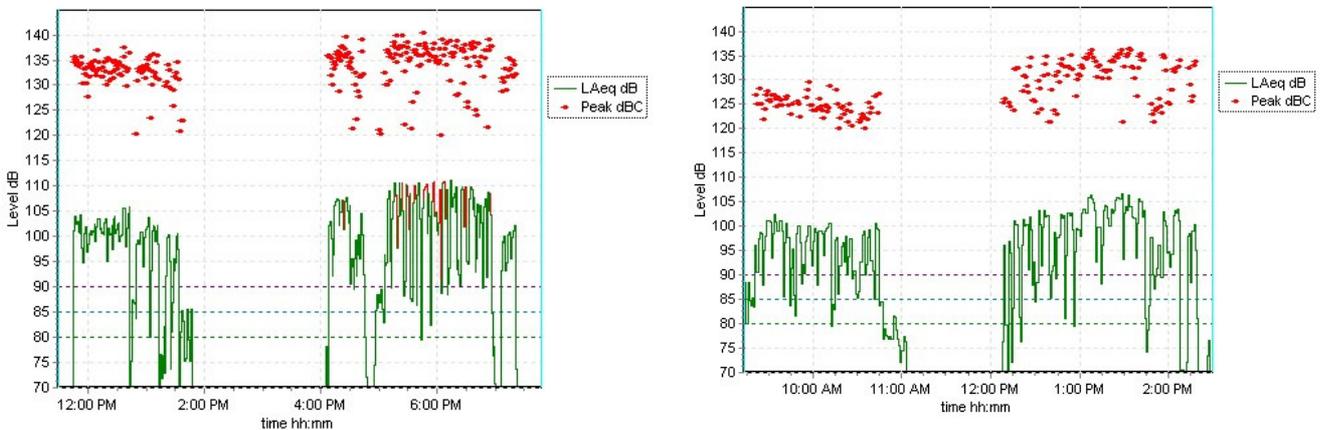
## **3. RESULTS**

Table 1 shows the reported weekly duration of time spent in either rehearsal or recording spaces, and the proportions of time spent using either headphone or loudspeaker amplification.

**Table 1:** Study time in rehearsal or recording spaces.

Total Recording or rehearsal (hours p.w.)	Group (hours p.w.)	Individual (hours p.w.)	Loudspeaker amplification (hours p.w.)	Headphone (hours p.w.)	Volume (subjective)	
					quiet	medium
Mean	Mean (hours pw)	Mean	Mean	Mean	quiet	medium
11.5	3.0	8.8	7.0	3.8	2.0	48.0
Stdev	stdev	Stdev	Stdev	stdev	loud	Max
9.6	4.0	9.5	6.9	6.6	31.0	1.0

The mean duration of rehearsal was 11.5 hours, with a wide range – the highest reported amount of weekly rehearsal was 40 hours. It is particularly notable that the majority of reported rehearsal uses amplification – either loudspeaker or headphone based, with the mean total amplification use 10.8 hours per week. Subjective volume levels reported by students were largely ‘medium’ or ‘loud’. Results from measurements of recording and rehearsal studios used by the different courses showed that sound pressure levels in performance rehearsal studios were generally extremely high, falling considerably above recommended levels. Figures 1a and 1b show 1minute LA<sub>EQ</sub> and Peak dBC over time for a band rehearsal room and a drum room recorded on the same day. The time spent in each room by particular groups can be clearly seen. Of 24 recordings made, the sound pressure levels in 20 of the measurements would put each of the groups in excess of the 2<sup>nd</sup> action level for personal daily exposure level (LEP<sub>d</sub>).



**Figure 1:** 1 minute LA<sub>EQ</sub> and Peak dBC over time for Band room (1a, left) and Drum room (1b, right)

From the analysis of the LA<sub>EQ</sub> data groups/individuals had a mean rehearsal duration of 2 hours and 13 minutes, and a mean LEQ in this time of 98dB. 98 dB LA<sub>EQ</sub> over 2 hours 13mins equates to a personal daily exposure level of 92.4 db LEP<sub>d</sub><sup>9</sup> for each rehearsal session, assuming that HPDs are not used. This presents a significant risk of NIHL if this pattern of exposure is maintained. As there is a reported mean duration of 7 hours per week of loudspeaker amplified rehearsal, this would suggest that students are likely to undertake an average of 3 such rehearsals per week, resulting in at least 3 days per week in which they exceed the recommendations for noise exposure through study rehearsal alone. Students on

music performance courses are therefore most highly at risk. The mean duration of exposure of students on music technology and record production based courses was much lower, and mean measured sound pressure levels were lower than 80dB in all of the recording studios and mixing rooms assessed, with a mean overall level of 70.5 dB. This group does however use a significant amount of headphone reproduction of sound. Actual sound pressure levels of headphone use are difficult to measure and have not been measured in this study. Self-reported headphone use for recording/mixing and rehearsal is considerably lower than loudspeaker amplification, but other studies<sup>2</sup> have shown that headphones can easily produce damaging sound pressure levels at the eardrum, so this is still considered a risk.

In addition to study based rehearsal, students involved in popular music based courses are also highly likely to have a high involvement in music based leisure activities and paid work (Table 2). Of the 100 students surveyed, 33 reported undertaking paid work in 'loud music' environments, particularly as DJs (16) and Sound Engineers (11). The mean hours worked per week was 6.9, with one student reporting working 40 hours per week.

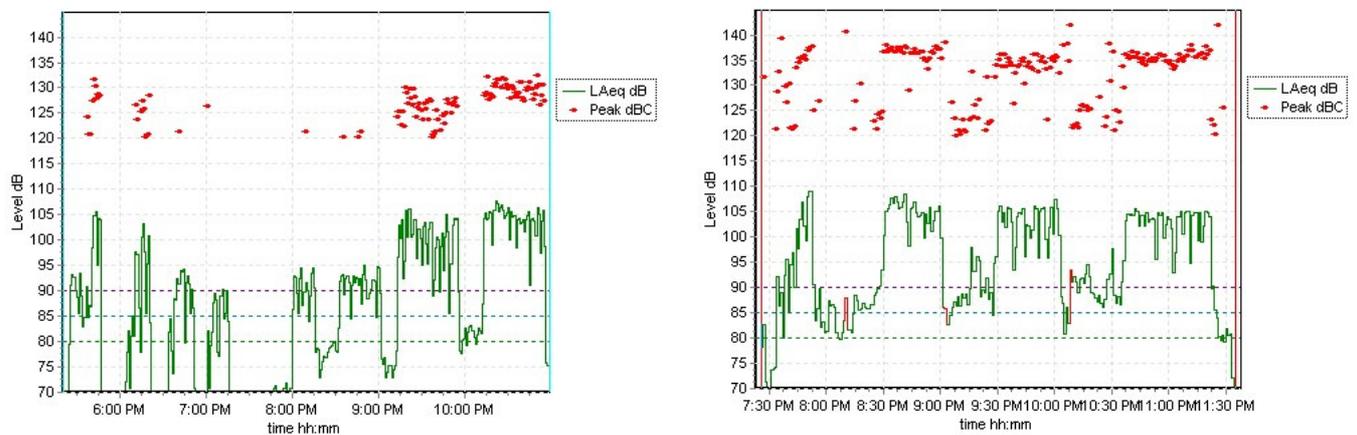
Leisure activities also tended to focus around music. 94% of students reported attending at least one live music concert per month, and 46% reported attending more than 3 concerts per month, with the majority staying at least 2 hours at each concert. In addition, 94% of the sample also attended a nightclub at least once per week, with 52% attending at least 2 times per month, and the duration of stay generally in excess of 2 hours. Ipod usage was also high, with 58% listening to a personal music player for more than 1 hour per day, with the majority using in ear headphones at a level of 60% or higher. Portnuff and Fligor<sup>2</sup> report that the sound pressure levels generated by an mp3 player through in ear headphones can easily exceed recommendations for safe levels.

. **Table 2:** *Time spent in leisure time and paid work in loud music environments*

<b>Live music concert attendance per month (% of students)</b>	<b>Duration of stay at live music concerts</b>	<b>Nightclub attendance per week (% of students)</b>	<b>Duration of stay at nightclubs</b>	<b>Work</b>
<i>none</i>	<i>&lt;1/2 hour</i>	<i>None</i>	<i>&lt;1/2 hour</i>	<i>number</i>
6.0	1.0	6.0	4.0	33.0
<i>1-2 times</i>	<i>up to 1 hr</i>	<i>Once</i>	<i>up to 1 hr</i>	<i>Mean hours</i>
43.0	2.0	38.0	1.0	6.9
<i>3-5 times</i>	<i>1-2 hours</i>	<i>2-3 times</i>	<i>1-2 hours</i>	<i>stdev hours</i>
32.0	17.0	46.0	10.0	8.1
<i>6-10 times</i>	<i>2-3 hours</i>	<i>4 or more times</i>	<i>2-3 hours</i>	<i>max hours</i>
12.0	39.0	6.0	34.0	40.0
<i>more than 10 times</i>	<i>3 hours+</i>		<i>3 hours+</i>	<i>Median hours</i>
2.0	31.0		43.0	4.0

Noise measurements from live music concerts at 2 music venues popular with students showed a range of sound pressure levels from 98dB to 112 dB, depending on position (figures 2a and 2b). The mean level in the audience, taken as an average across 5 readings in different positions in the room at one venue was 98.9 dBA while at the other venue it was

103.6 dBA, each over a 4.5 hour period. The highest reading was 106.9 dBA in one venue as a 4.5 hour  $L_{EQ}$ , for a position close to the stage, with the last set of the evening giving a 45 minute  $L_{EQ}$  of 112.1 dB. From a visual analysis, few if any of the audience were wearing hearing protection. These measurements are closely in line with those reported by the Health and Safety Executive<sup>13</sup> for live music events. A review of studies by HSE<sup>5</sup> also reports that nightclub dancefloors usually range between 100 and 106 dBA in noise levels, resulting in a 2 hour stay at a loud music event or nightclub (such as that shown in figure 2b) likely to result in a personal noise daily noise exposure of between 94 dB  $LEP_d$  and 100db  $LEP_d$ . Each visit is therefore likely to put the listener at risk of hearing loss if HPDs are not worn. The frequency of attendance and the noise levels of venues and clubs suggest a high risk of development of NIHL amongst this sample group.



**Figure 2:** 1 minute  $LA_{EQ}$  and Peak dBC over time at the FOH position for two live event venues (2a, left and 2b, right)

Students were also asked to report if they had had any of the symptoms commonly associated with NIHL - tinnitus, temporary threshold shift or pain/sensitivity (hyperacusis) whether temporarily or permanently, and were also asked to identify if they had any specific concerns about their hearing. They were also asked to state if they had received any education about noise regulations or hearing loss as part of their course (Table 3).

**Table 3: Symptoms of hearing damage, use of HPDs and reported education received**

<b>Symptoms exhibited after loud music (% of students)</b>	<b>HPD use in music environments (% of students)</b>	<b>Education/publicity about noise (% of students)</b>
<i>Tinnitus</i>	<i>Always</i>	<i>Education on NIHL</i>
58.8	7.0	64.0
<i>Threshold Shift</i>	<i>Usually</i>	<i>Education on Noise regulations</i>
42.3	11.0	51.0
<i>Pain</i>	<i>Occasionally</i>	<i>Noise meters in studios/rehearsal rooms</i>
16.0	37.0	35.0
<i>Concerns</i>	<i>Never</i>	<i>Earplug demos</i>
27.0	42.0	21.0

76% of students reported having had at least one of the three given symptoms after either attending a music event or being in a rehearsal/recording. The most common symptom was tinnitus, with 58% of students reporting having had it at some point, and 4 reporting permanent tinnitus in at least one ear. 27% identified particular concerns, including one instance of regular pain in one ear, and 4 reporting noticeable reduction in hearing levels in one ear. 64% of the sample reported having had education on hearing loss and 51% having had education about noise levels. Only 35% of the students reported having sound level meters in their studios/rehearsal rooms and only 21% had had a demonstration of musicians earplugs, indicating that while information may be given to the students, it is not necessarily backed up with the required tools for them to make informed choices.

**Table 4: Types of HPD use and reasons for wearing/not wearing**

<b>Types of HPD used (non-exclusive)</b>	<b>Reasons for using HPDs (non-exclusive)</b>	<b>Reasons for not using HPDs (non-exclusive)</b>
Foam plugs	Concerns about NIHL	Uncomfortable
34.0	43.0	13.0
Wax/silicon plugs	Prevent tinnitus	Hassle
5.0	26.0	16.0
muffs	Increase comfort of loud sounds	Forget
9.0	22.0	34.0
Molded plugs	Job requirements	Expensive
4.0	9.0	10.0
Universal musicians plugs	Stress prevention	Difficulty communicating
15.0	7.0	22.0
custom musicians	pain prevention	don't need
5.0	13.0	30.0
buds/tissue		affects perception of music
1.0		27.0
Other		can't hear others playing
		19.0

Despite the high instances of TS and Tinnitus, only 18% of the students reported 'always' or 'usually' wearing HPDs if they knew that they were likely to be in a loud music environment. Those who wore HPDs generally reported doing so out of concern for their hearing to prevent tinnitus or increase comfort of loud sounds, however the majority still used foam plugs as their main form of HPD. Foam plugs are not ideal for music use as they have a significant effect on frequency content, disproportionately affecting high frequencies, and therefore making listening to music or communicating difficult. Of those who reported not using HPDs at some point, 68% reported problems in communication, music perception or hearing other musicians as a reason for not wearing HPDs. Another 30% reported 'not needing' hearing protection as a reason for non-use, while 34% reported that they forgot to use hearing protection at some points.

#### **4. CONCLUSIONS**

The students in the sample generally exhibited behaviours which would place them at significant risk of Noise Induced Hearing Loss. Both study and leisure activities regularly caused the majority of students to exceed the recommended daily noise dose at least on some occasions, in some cases by extremely high levels. The patterns of behaviour self-reported by the students and the measurements taken of sound pressure levels suggest that a high proportion of these students potentially exceed the daily noise dose recommendations several times per week. Despite a high proportion of students reporting education on noise loss, the levels reported/measured and the low use of hearing protection devices for rehearsal/leisure time suggests that this group is at a disproportionately high risk of long term hearing damage. At highest risk are those who are specialising in performance of popular music, as they are likely to exceed the UK noise dose recommendations on a nearly daily basis. These students are largely placing themselves in a long term health risk.

This suggests that a more robust approach to education on noise and hearing is needed in popular music courses. In particular, while NIHL and Noise regulations were being covered by courses, this information was insufficiently backed up with practical work and information to enable the students to improve their understanding of the actual sound levels to which they were exposing themselves, and to allow them to experience the effects of frequency agnostic hearing protection devices such as the ER-20 musicians earplugs. Courses need to generally improve their education methods and in particular provide visible noise monitoring in studios as a matter of priority.

#### **ACKNOWLEDGMENTS**

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