Recreational Noise Exposure in New Zealand

Kim N Dirks (1), Ingrid Dekker (2), Laura Scheib (3) Kierrin Svoboda (4) and Aanchal Sharma (5)

(1)Section of Epidemiology and Biostatistics, School of Population Health, Faculty of Medical and Health Sciences,

The University of Auckland, Auckland, New Zealand
(2) Dilworth Hearing Clinic, Remuera, Auckland, New Zealand
(3) Dilworth Hearing Clinic, Epsom, Auckland, New Zealand
(4) National Hearing Care, Parnell/Henderson, Auckland, New Zealand
(5) Faculty of Medical and Health Sciences, The University of Auckland, Auckland, New Zealand

A paper previously presented at ISSA 2010, 29-31 August 2010, Auckland

Abstract

In New Zealand, legislation requires that the maximum workplace noise exposure not exceed an LAeq 8h of 85 dB in order to avoid the risk of developing a noise-induced hearing loss. However, this assumes that a worker is not exposed to any significant additional noise in their leisure time. For many young urban people in particular, much of their exposure may actually be attributed to noisy recreational rather than occupational activities. In order to begin to quantify recreational noise exposure amongst this group, sound level measurements associated with various popular recreational activities were made (such as nightclubs and live music events), and questionnaire data were collected and analysed along with some lab-based measurements associated with the use of personal listening devices (PLDs) and individual behaviour in the presence of background noise.

Sound levels in nightclubs were found to be around 105 dBA. At this level, the daily maximum noise dose is exceeded in about 5 minutes. Results of a questionnaire suggest that exposure times are typically 2-3 hours with approximately 20% of people typically staying for longer than 3 hours. For live music events (rock concerts), sound levels were found to be 105-108 dBA with exposures ranging from 3-4 hours, with the daily allowable maximum exceeded in about 2.5-5 minutes. While the noise levels on buses and trains are typically low (73-82 dBA with the highest levels being recorded aboard old trains), lab-based studies of behaviour in the presence of background train and bus noise suggest that for a typical commute of one hour, about half of commuters exceed their daily dose based solely on their PLD use. Of these, about 5% of PLD users have their devices turned up to very high levels, irrespective of background noise.

Introduction

Over the last decade, there has been a significant increase in the number of claims made in New Zealand through the Accident Compensation Scheme (ACC) for occupational Noise-Induced Hearing Loss (NIHL) [1]. In order to help prevent NIHL, Regulation 11 of the Health and Safety in Employment Regulations 1995 requires that the maximum workplace noise exposure not exceed an $L_{Aeq\ 8h}$ of 85 dB [2]. Although claims can only be made for hearing loss acquired through workplace exposures, in terms of damage, the ear makes no distinction between occupational and recreational noise.

Depending on the choice of activities, for many people, the noise levels to which they are exposed in their leisure time can represent a significant contribution to their overall noise dose. The present study begins to quantify leisure noise exposures of New Zealanders by taking measurements of noise levels during activities deemed to be noisy and carrying out survey work to estimate the amount of time people spend involved in these activities so that the associated 'noise dose' may be calculated.

These are considered alongside a range of occupational noise exposures to get a handle of the total noise dose to which people are exposed.

Noise exposure is of concern because it can cause a permanent loss in hearing though damage to hair cells in the cochlea. Noise exposure can also cause a Temporary Threshold Shift (TTS) which is a temporary sensorineural loss of hearing that recovers within about 24 hours after exposure [3] and occurs as a result of a decrease in stiffness of the stereocilia of the outer hair cells [4].

While permanent threshold shifts are generally acquired over many years of exposure, TTSs are associated with specific high noise-exposure events so may be a good indication of the impact of a specific event or activity on the hearing system. NIHL is typically associated with a hearing notch in the 4–6 kHz region [5].

There are very few studies of leisure noise carried out in New Zealand, yet there has been a lot of interest in this topic in the international literature. An early study looking at leisure noise exposure carried out in the UK in 1985 concluded that it was unlikely that leisure noise posed a significant health risk [6].

This is based on measurements of noise

levels that were found to be comparable to what was found in industrial environments but with significantly reduced exposure times. However, later reviews suggest that the amount of social noise to which people are exposed has increased in recent years [7, 8]. Studies have shown an increase in the prevalence of personal listening device usage as well as increased sound levels in nightclubs [9, 10], suggesting an increase in overall recreational noise exposure [11]. This exposure is in addition to any occupational exposure one may be exposed to during the course of a working day.

Therefore the percentage of maximum permitted sound exposure (when considering both occupational and recreational noise exposure) is given by,

$$\frac{10^{L_{AEqW}/10} \times t_W + 10^{L_{AEqR}/10} \times t_R}{10^{85/10} \times 8h} \times 100\%$$

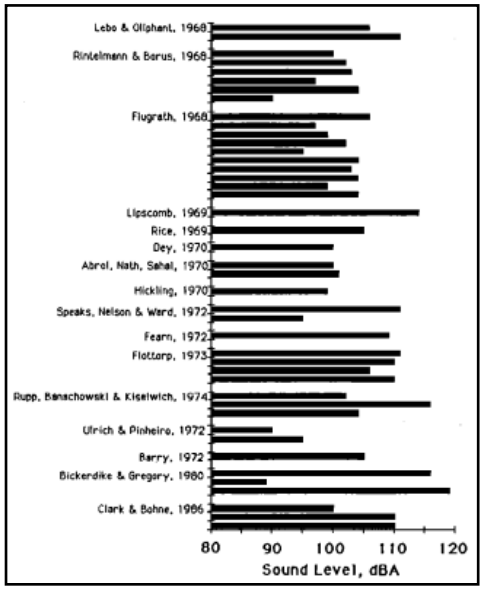

Figure 1. Sound level measurements from studies of live music events [12]

where the subscripts W and R refer to 'workplace' and 'recreational' respectively and the exposure times given by t in hours. While for many there is a clear distinction between what is workplace noise and what is recreational noise, for those working in hospitality or in the music industry, the distinction may not be so clear.

Some of the most significant sources of recreational noise amongst young urban adults in New Zealand are nightclubs, live music concerts and the use of personal listening devices (such as IPods and MP3 players). In 1991, a comprehensive review was carried out into the sound levels associated with live music events reported in the international literature (see Figure 1) [12]. The study found a mean level of 103 dBA and a range of 89 dBA to 119 dBA. As an indication, if a person were exposed to this average level of noise in an industrial setting, their safe exposure time would be approximately 7 minutes.

The use of personal listening devices has increased immensely with the introduction of MP3 players and IPods into the market [13]. Such devices have considerably better battery life and better quality sound than earlier devices. Recent studies include that of Serra et al (2005) which showed a sound level output ranging from 75 to 105 dBA [14], that of Trask et al (2006) which showed levels ranging from 65 dBA to 111 dBA [15] and that of Farina (2007) which suggests levels in the range of 62 to 103 dBA [16].

Research Questions

In the present study, nightclubs and live music events were chosen as the main activities of interest. For these activities, the noise level is largely beyond the control of the patron, other than the option to attenuate the sound through the use of hearing protection or to stay clear of speakers. Also considered in the present study is the use of personal listening devices. While the choice of volume settings and listening times are entirely within the control of the user, the individ-ual's noise dose will be affected by the environment or activity in which the device is used. For example, if a person listens to an IPod while commuting, the length of their commute influences the duration of their exposure and the background noise of the bus or train in which they are commuting will affect their choice of volume setting. This different source of recreational noise is also considered in some detail.

Specific Research Questions

The specific research questions being addressed in this paper are:

1) What are the noise levels associated with night-clubs and live music in New Zealand and how do these compare with the Health and Safety In Employment regulations?

2) What are the noise doses associated with nightclubs and live music events? To what extent do exposures from live music events induce temporary threshold shifts?

3) What are typical IPod/MP3player exposures for young adults? How does this exposure change if the listening device is being used while taking public transport (i.e. in conditions of high levels of background noise)?

4) To what extent is hearing protection used and what are the consequences of use or non-use?

ACOUSAFE
NOISE CONTROL SOLUTIONS
resource management
environmental noise control
building and mechanical services
industrial noise control
Nigel Lloyd, phone 04 388 3407, mobile 0274 480 282, fax 04 388 3507, nigel@acousafe.co.nz

Methodology

Noise measurements were made using a Bruel and Kjaer Type 4443 Logging Noise Dose Meter.

Nightclubs

Sound level measurements were taken at three nightclubs around Auckland and were visited three times each at different times of the night to see if noise levels changed throughout the course of the evening. One played predominantly house music, one played live rock music and one played Top 40 chart music. Each of the measurements taken lasted 20 minutes.

A questionnaire aimed at university students asked a range of questions associated with noise exposure. In terms of night-clubs, the participants were asked how often they attended and the duration of a typical visit. The sample size was 80.

Live Music Events

Sound level measurements were taken throughout the duration of three live music events in Auckland. The hearing thresholds of people working at these events (10 in total) were measured before the event and their TTSs were measured immediately following the event. They were also asked about their use of hearing protection while working. In the university questionnaire, students were asked how often they attended live music events.

Personal Listening Device (IPod/ MP3 Player) Use

A total of 16 subjects were recruited to investigate their be-haviour in terms of their IPod/MP3 player usage and volume setting behaviour. The subjects were asked to listen to a podcast, their favourite song and a generic song chosen by the researcher in a quiet background environment and also in a variety of different levels of background noise intended to simulate what would be experienced while commuting on public transport.

Sound recordings of real Auckland buses and trains were made to simulate real conditions as much as possible. The signal-to-noise ratios (SNR using HINT) of the subjects were also tested to see whether this had any impact on their listening behaviours. In the university questionnaire, students were asked about how often and for how long they listened to their IPod/MP3 player and in what sort of envi-ronments such listening occurred.

Results

Nightclub Attendance

Figure 2 shows the results of the noise levels recorded at the three nightclubs across Auckland. Note that at Club 2, the large variability is a reflection of the fact that live music was being played. The sound levels dropped considerably during intervals.

Apart from this, sound levels were found to vary little throughout the course of the night and were comparable to the sound levels found in studies reported

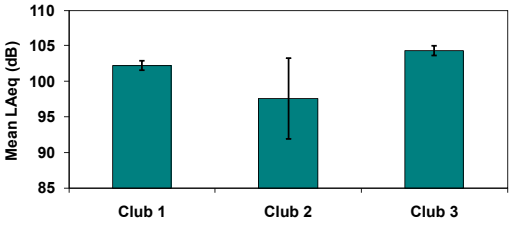

Figure 2. Noise levels associated with nightclubs in Auckland

MARSHALL DAY Acoustics

Consultants in Architectural & Environmental Acoustics

Auckland - Christchurch - New Plymouth - Wellington - Adelaide - Melbourne - Sydney - Guangzhou - Dublin

www.marshallday.com

upon in the literature.

In terms of the Health and Safety in Employment requirement, if such exposures were being experienced in the workplace (as they would be for those working in the nightclubs), the maximum allowable noise dose would be reached in as little as 15 minutes.

For those attending the nightclub in their leisure time, their nightclub exposure is in addition to what they may have experienced throughout the course of their working day.

Figure 3 shows the 'maximum allowable' exposure time when also taking into account this workplace exposure in addition to their nightclub noise exposure.

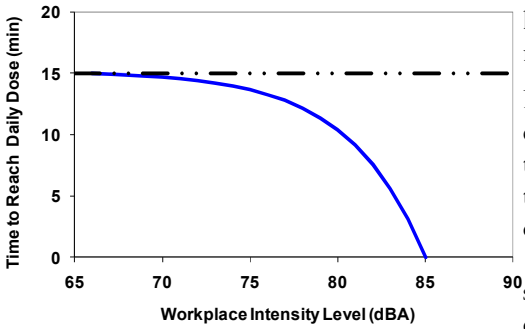

Figure 3. Time to reach daily noise dose from attending a nightclub as a function of the workplace exposure (8-hour LAeq).

It can be seen that the exposure time drops from 15 minutes for those working in quiet environments to 0 minutes for those that reach (or indeed exceed) their daily workplace maximum allowable noise dose.

Figures 4 and 5 show the results of the questionnaire in which 80 university students were asked how often they attended nightclubs and for how long they stayed on a typical night out.

Based on the survey data, while people claim to not go to nightclubs that often (about 40% claimed to have gone 1–3 times in the last six months), only 25% claim to stay less than two hours on average. About 5% claim to stay for more than 5 hours on average. This is equivalent to 20 times the daily allowable dose. This may also be typical of the noise dose of those working in nightclubs.

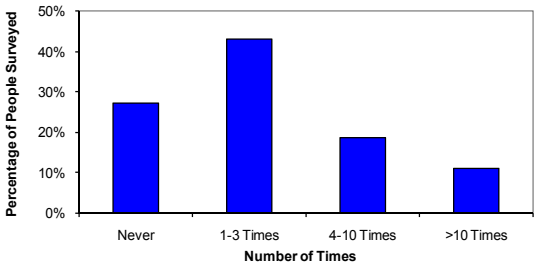

Figure 4. Response to question "How often have you visited a nightclub (or bar with loud music) in the past six months?"

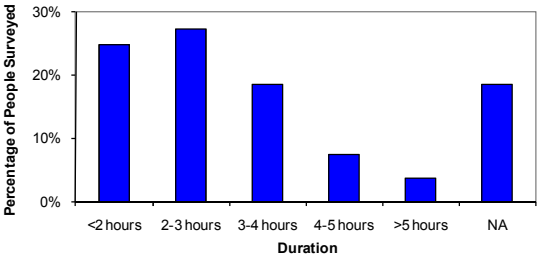

Figure 5. Response to question "When visiting a nightclub, how long did you stay on average?"

While patrons can choose to wear hearing protection (though nearly nobody ever does according to the results of our survey), those that are working in this environment need to be able to communicate with patrons as part of their job so hearing protection is not necessarily a viable option.

Table 1 shows the sound levels (in dBA) for each of the events along with the duration of the event and the factor of the daily maximum allowable dose that a person would receive while attending this particular event. Note that for one event, the factor daily allowable dose is 85 (or 8500%)!

Table 1. Sound levels associated with live music events

Event	Event Level (dBA)	Dura-tion (h)	Time to reach Max (min)	Factor of Daily Dose
1	108	3.5	2.46	85
2	105	4.0	5.02	49
3	108	3.0	2.68	67

Table 1. Sound levels associated with live music events

Live Music Events

Live music events are different in the sense that people stay for a specified amount of time (i.e. the duration of the event). Sound level measurements were taken through the duration of three live events in Auckland. In addition, the hearing of ten subjects working in the events industry was tested before the event, and their TTSs were measured immediately following the event. The participants involved in the study were also asked about their habits with regard to hearing protection usage while at work. In the student questionnaire, people were asked how often they attended live music events and whether or not they used hearing protection.

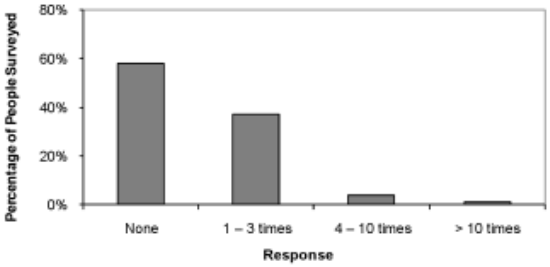

Figure 6. Response to 'How often have you been to a live concert (or similar noisy music event) in the past six months"?

Figure 6 shows the results of the survey question which asked university students how often they attended live music events. Over half said that they hadn't been over the last six months while about one in three said they had been one to three times. While this represents a frequency of up to about once every two months, those working in the events industry will be attending these on a much more frequent basis.

Not only do they attend the actual concert, they are also involved in the pre-concert testing and rehearsals. In addition, in the events industry, there is a well developed 'concert culture' whereby a popular recreational activity is attending concerts at other venues across the country by way of free passes from others in the industry. As a result, such people will be receiving noise doses of this level on a very regular basis.

Despite this very high noise dose, it was interesting to find that of the ten people for which hearing tests were performed prior to an event, all had normal thresholds. This includes one subject who had been working in the events industry for 20 years!

This highlights the large variability there must be in the sensitivity to noise amongst people in the population.

Immediately following the music event, the same ten subjects were tested for their TTSs.

A TTS index was developed which was defined as the average of the threshold shifts observed for frequencies of 2000 Hz and 4000 Hz. The TTS indices of the subjects ranged from zero to 14 dBA. Not surprisingly, the two subjects who wore hearing protection showed significantly lower TTS indices that the others, as shown in Figure 7. In the survey of university students, very few (≈8%) admitted to using hearing protection while attending concerts (see Figure 8).

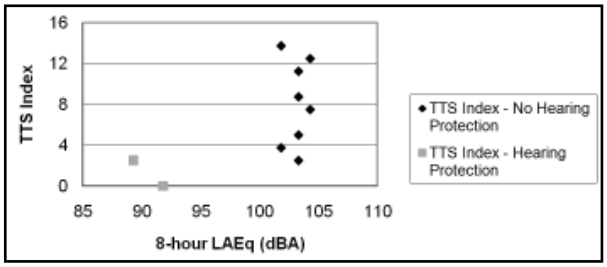

Figure 7. Effect of hearing protection on TTSs for employees of live music events.

IPod/MP3 Player Usage

For many young people, it is likely that their use of IPod/MP3 player represents a significant fraction of their daily noise dose. In the university student questionnaire, it was found that of those surveyed, about 10% listened to their IPods/MP3 players on a loud setting for more than 10 hours a week on average (see Figure 9), and about 5% listened to their IPod/MP3 player for more than 10 hours per week while commuting or exercising near a busy road. In other

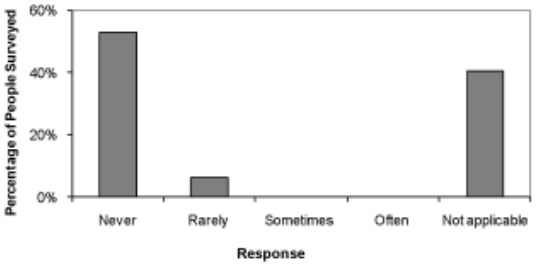

Figure 8. Response to "Do you use earplugs (or other hearing protection) at concerts?"

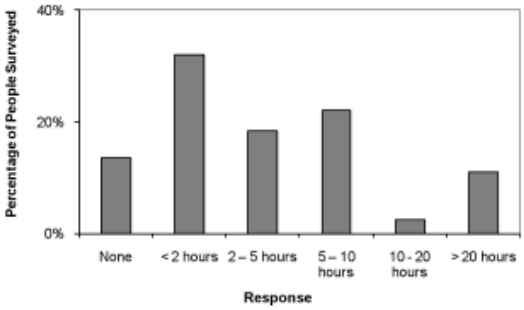

Figure 9. Response to "How many hours did you spend lis-tening to music using headphones with the volume turned up high over the last two weeks?"

words, a significant portion of this listening occurred in an environment with a noisy background from cars or, buses or trains.

Given that many people listen to their IPods while commuting, in order to get a good representation of noise exposure levels from IPods, the listening behaviours of people were investigated for a range of different levels of background noise.

More specifically, 16 subjects were asked to set their IPod/MP3 player to their preferred listening level for a pod-cast, their favourite sound and a generic song for specific levels of background noise recoded aboard Auckland public transport and fed back into the ear canal of the subjects.

Assuming a commute of one hour, Table 2 shows the percentage of the subjects whose preferred listening volume would result in them exceeding their occupational noise dose simply by setting their IPod to their preferred noise level and listening to it during their commute.

Environment	Podcast	Generic Song	Favourite Song
Control	6%	19%	13%
Quiet	38%	31%	44%
Moderate	75%	56%	81%
Loud	87%	87%	81%

Table 2. Percentage of people exceeding their daily dose using a personal listening device assuming a one-hour commute

In this table, 'Quiet', 'Moderate' and 'Loud' represent different levels of recorded commuting noise being played back to the subjects and 'Control' represents a quiet environment free of any recorded background noise.

It can be concluded from these results that in environments of moderate or loud background commuting noise (such as one would experience on an old train for example), the majority of people would be exceeding their daily noise dose simply by listening to their IPod while commuting.

This occurs whether the entertainment is a podcast, their favourite music or generic music, such as what might be experienced while listening to a music station on the radio.

One particualry interesting observation from this study was that of the 16 subjects, there was one who consistently turned the sound up to a high level, irrespective of the level of background noise (whether listening to a podcast, their favorite song or a generic song).

When investigated further, it was found that this particualr subject also had a very high (poor) signal-to-noise score (using HINT) relative to the other subjects (a value of 8 compared to all of the others that fell in the range of 0 to 2) despite having a normal audiogram (see Figure 10).

A possible link between a poor signal-to-noise score and a predisposition towards high listening volumes is something that warrents further investigation.

Discussion and Conclusions

The sound levels in nightclubs and live music events in New Zealand are such that the daily noise dose is reached in a matter of minutes.

These levels are not dissimilar to those reported in studies carried out overseas.

For those attending for recreational purposes, these exposures may occur relatively infrequently, however for those working at such venues these exposures may be a daily occurrence.

Moreover, the events industry is such that workers spend a great deal of their leisure time attending other events around the country, adding to their noise dose.

While our sample size was small, it was found that the TTSs were considerably reduced for the two workers in the events industry that wore hearing protection compared with the eight that didn't.

Therefore it is expected that the consistent use of hearing protection will significantly reduce their chances of developing permanent hearing loss in the long term.

Although the noise doses experienced by workers and patrons attending these events were excessive (49—85 or 4900%—8500% the daily allowable occupational noise dose), there was one subject who had been working in the events industry for 20 years (without using hearing protection) who was found to have normal hearing and a normal signal-to-noise ratio score.

Clearly there is a large variability in the population when it comes to the sensitivity of ears to noise damage.

The recent increase in the popularity of portable listening devices has resulted in raised concern about the safety of their use, especially as many people listen while in environments with high levels of background noise such as commuting.

In particular, this study found that 6%, 19% and 13% while listening to podcasts, generic songs and favourite songs, respectively, would exceed the daily noise dose in one hour in a quiet background environment (Control), and that these increased to 87%, 87% and 81%, respectively, for a one—hour commute on a noisy bus or train.

While the bus and train noises themselves are of limited concern (ranging from about 70 to 80 dBA), the impact on IPod/MP3 volume setting behaviour is quite significant, and worse if the exposure occurs in addition to significant amounts of occupational noise exposure.

Acknowledgments

The authors wish to thank the Deafness Research Foundation for financial assistance with this work.

The authors also wish to thank Gavin Coad for his technical assistance with this project. Aanchal Sharma was supported by a Faculty of Medical and Health Sciences (U of A) Summer Studentship.

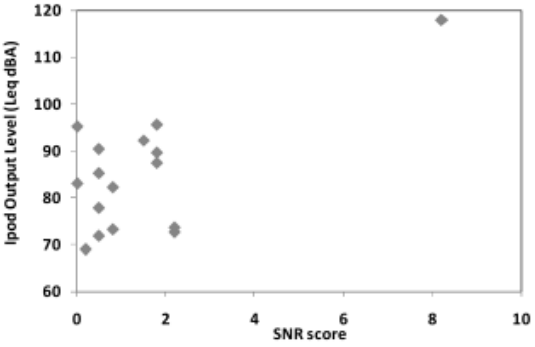

Figure 10. Signal-to-noise ratio (based on SINT) of 16 subjects as a function of their PLD output level.

References

1. **J. Wallart**, Noise Induced Hearing Loss in New Zealand Industry (Accident Compensation Corporation Report, Wellington, 2006)

2. **Occupational Safety and Health Service**. Approved Code of Practice for the Management of Noise in the Workplace (Department of Labour, Wellington, 2002)

3. **R.A. Dobie**, "A method for allocation of hearing handi-cap" Otolaryngology–Head and Neck Surgery. 103, 733-739 (1990)

4. **U. Bapat and N. Tolley**, "Temporary threshold shift due to recreational firearm use" J. Laryngology and Otology. 121, 927-931 (2007)

5. **Department of Labour**, "Noise Induced Hearing Loss–A Guide for Medical Practitioners" http://www. osh.dol.govt.nz/order/catalogue/76.shtml

6. **A.C. Davis, H.M. Fortnum, R.R.A. Coles, M.P. Haggard, M.E. Lutman**, "Damage to hearing arising from leisure noise: A review of the literature" (MRC Institute of Hear-ing Research, London)

7. **S.P.M.D. Mostafapour, K.M.S. Layhargoue**, G.A.M.D. Gates "Noise-induced hearing loss in young adults: The role of personal listening devices and other sources of lei-sure noise" Laryngoscope 108(12) 1832-1839 (1998)

8. **R. Bradley, H. Fortnum, R. Coles**, "Research note: Patterns of exposure in schoolchildren to amplified music" British Journal of Audiology 21, 119-125 (1987)

9. **A. Axelsson**, "Leisure noise exposure in adolescents and young adults" Journal of Sound and Vibration 151(3) 447-453 (1991)

10. **S. Sadhra, C.A. Jackson, T. Ryder, M.J. Brown**, "Noise exposure and hearing loss among student employees working in university entertainment venues" Annals of Occupational Hygiene 46(5) 455-463 (2002)

11. **P.A. Smith, A. Davis, M. Ferguson, M.E. Lutman**, "The prevalence and type of social noise exposure in young adults in England" Noise and Health 2(6) 41-56 (2000)

12. **W. W. Clark**, "Noise exposure from leisure activities: a review" Journal of the Acoustical Society of America 90: 175-181 (1991)

13. **D. A. Fergusson, C.F. Greer, M.E. Reardon**, "Uses and gratifications of MP3 players by college students Are Ipods more popular that radio?" Journal of Radio Stud-ies 14(2) 102-121 (2007)

14. **M.R. Serra, E.C. Biassoni, U. Richter, G. Minoldo, G. Franco, S. Abraham, et al**, "Recreational noise exposure and its effects on the hearing of adolescents. Part I: An interdisciplinary long term study" International Journal of Audiology 44(2) 65-73 (2005)

15. **D.K. Trask, B. Abkas, N. Jous**, "Listening habits and noise exposure of MP3 player users" Otolaryngology–Head and Neck Surgery 135(2, Supplement 1) 142-143 (2006)

16. **A. Farina**, "A study of hearing damage caused by personal MP3 players" in Audio Engineering Society (New York, 2007) ❑

SOUNDGUARD

Noise Control Materials

MARINE – INDUSTRIAL - RESIDENTIAL

Deci-Tex 3-D acoustic materials: quietly making their presence felt
Vertical lapped non-woven fibre technology

Engineering Acoustically Tuned Sound Absorption

Volpower NZ LIMITED

Phone: 09-274-4305, Fax: 09-274-4306, Email: reception@volpower.co.nz
www.volpower.co.nz