Beyond Music: Auditory Temporary Threshold Shift Following Exposure to a Live Rock Concert

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Abstract

This study investigated the temporary threshold shift and noise dose of 40 college students after exposure to live rock music for ½, 1, 1 ½, and 2 hours, respectively. The mean personal exposure level for the subjects was 101.8 dBA with a maximum peak pressure mean of 128.5 dBA. The average threshold shift over all the frequencies was 4.87 dB for the ½ hour group, 9.64 dB for the 1 hour group, 10.78 dB for the 1 ½ hour group, and 12.25 dB for the 2 hour group. These threshold shifts indicate that even short term exposures to music over 90 dB can cause temporary changes in hearing and could cause permanent hearing loss through frequent exposure. There were no significant differences in threshold shifts between males and females.

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Noise induced hearing loss is a permanent hearing impairment resulting from prolonged exposure to high levels of noise. Excessive noise exposure is the most common cause of hearing loss. Twenty-five percent of the work force in the United States is regularly exposed to potentially damaging noise (Suter and von Gierke, 1987). Because of occupational risk of noise induced hearing loss, there are government standards regulating allowable noise exposure for workers. However, recent studies show an alarming increase in noise induced hearing loss in young people. Evidence suggests that loud rock music along with increasing use of portable stereo systems with earphones may be responsible for this phenomenon.

Musicians and hearing specialists have become aware that rock and classical music have the potential to produce noise induced hearing loss. More recently, concert attendees are also beginning to recognize the danger of listening to loud music. Hearing loss resulting from exposure to repeated amplified music in musicians and music consumers is described in the literature (Melnick, 1997; Chasin, 2000; Sadhra, Jackson, Ryder, and Brown, 2002; Yassi and Pollock, 2003). Music is an integral part of our lives, but if played too loud can cause permanent and irreversible damage to our hearing. Whether the music is at a rock concert, from a classical orchestra, your personal stereo system with headphones or earbuds, or your home or car stereo, if the music is played too loud for too long, hearing damage is inevitable. The risk of hearing loss does not exist only after prolonged exposure. Short-term exposure to very high sound levels can also cause hearing loss.

Continued exposure to noise above 90 decibels, over a period of years will cause damage to hearing. Exposure to loud music is somewhat different from industrial noise, however, due to the intermittent nature of music – music is filled with both quiet and intense passages. This intermittent nature of music offers some protection for the ear. However, sound levels at concerts can be in the range of 120 to 140 decibels, well beyond the 100 decibels normally recognized as the threshold at which short-duration exposure (approximately 1 hour) can cause permanent hearing loss. The loss is caused by damage to fragile tissue strands within the cochlea. These strands are called hair cells because they resemble tiny hairs. They move with the fluid in the cochlea to stimulate the electrical impulses in the auditory nerve. The hair cells become damaged in the presence of loud noise.

The ear provides several warning signs when subjected to potentially damaging sound levels. Temporary hearing loss is one indication and ringing in the ears is another. A temporary change in hearing is referred to as temporary threshold shift (TTS). After exposure to loud noise hearing thresholds are poorer than prior to the exposure. The effects may last minutes, hours, or days depending on factors such as duration of exposure, intensity of the noise, pitch of the noise, and other physiological factors. Many studies have shown that prolonged and long-term exposure to loud music results in permanent hearing loss; however few studies have investigated the effects of short-term exposure. This study was designed to investigate test-retest differences (TTS) as a function of gender, ear, and frequency in conditions of quiet before and after exposure to live rock music. Additionally, noise levels and noise dose were measured from which exposure over time can be extrapolated.

Method

Subjects

Subjects in this investigation were 40 college students (20 males and 20 females) between the ages of 21 and 24 years (M = 22.1). In addition to a willingness to participate in the study, inclusion criteria included (1) no known hearing loss and (2) normal middle ear function (Tympanogram Type A) at time of participation/evaluation. Subjects were asked to provide information regarding attendance at live music venues, including both number of times per week, month, etc. and approximate length of each exposure.

Procedure

Pre- and post-exposure audiometry was used to determine hearing thresholds at all frequencies from 500 Hz through 8000 Hz. Baseline audiometric thresholds were obtained for each subject approximately 30 minutes prior to exposure. Following administration of the baseline audiogram, each subject was fitted with a personal dosimeter and instructed to attend the live music concert for periods of ½, 1/ 1 ½, or 2 hours (5 males and 5 females per time period).

Immediately following exposure, subjects returned to the mobile testing unit for follow-up evaluation of hearing thresholds. Subjects were asked to provide information regarding their perceptions of their hearing and whether or not they were experiencing tinnitus (ringing or buzzing in the ears).

Results

The mean personal exposure level for all subjects was 101.8 dB(A) with a maximum peak pressure mean of 128.5 dB. Tables 1 – 4 illustrate mean threshold shifts across the frequencies for the four subject groups. The average threshold shift over all frequencies was 4.87 dB for the ½ hour group, 9.64 dB for the 1 hour group, 10.78 dB for the 1 ½ hour group, and 12.25 dB for the 2 hour group. The greatest differences were seen in the 3-6 kHz frequency range. There were no significant differences in threshold shifts between males and females.

Forty-three percent of the subjects reported tinnitus after exposure. While no subjects in the ½ hour exposure group reported tinnitus, those experiencing tinnitus included two subjects in the 1 hour group, seven subjects in the 1 ½ hour group, and eight subjects in the 2 hour group.

Reports of attendance at live rock music venues ranged from two times per month to two times per week (M = 1.56 times per week). Subjects reported length of duration of each attendance ranging from one hour to as much as four hours (M = 1.72 hours).

Discussion

The results of this study indicate that any exposure to music over 90 dB causes temporary threshold shift, particularly in the higher frequencies. Results reveal that increased exposure times cause greater threshold shift. Since temporary threshold shift and tinnitus are key factors in determining potentially damaging sound levels, the results of this study suggest that college students need to be educated about noise induced hearing loss.

Traditional concerns about noise induced hearing loss have focused on industrial settings with continuous, high levels of noise. The Occupational Safety and Health

Administration (OSHA) established guidelines for exposure to continuous levels of noise that have greatly reduced noise induced hearing loss in these types of settings. Unfortunately, OSHA's guidelines for sound exposure do not translate well for those who enjoy loud music. The type of exposure that a concert attendee is subjected to is difficult to quantify and control. Sound levels at live concerts can range from 90 dB to 130 dB. Sound levels are not steady; the music may have both loud and softer passages. Other factors that complicate measurement of sound levels include the size of the concert area, distance from the sound source and amplifiers, and reverberation factors. Because it is difficult to quantify the sound level for any concert, it becomes difficult to establish safe exposure limits. Frequency of attendance at live music venues is also a factor that must be considered.

A large body of research details exposures to musicians and to individuals attending rock concerts and loud clubs. Clearly, musicians are at risk for noise induced hearing loss since they are subjected to loud music on a daily basis. Studies show that long-term exposure to loud music will cause noise induced hearing loss, particularly among students who listen to amplified music and/or work in entertainment venues (Metternich & Brusis, 1999; Sadhra, et.al., 2002). On the other hand, Clark (2005) analyzed published sound levels of rock concerts and found that the geometric mean was 103.4 dB. He concluded that it is reasonable to expect that attendees at rock concerts are routinely exposed to sound levels above 100 dBA, but that the risk of sustaining a permanent hearing loss is minimal, and is limited to those who frequently attend such events. Studies of temporary threshold shift in listeners attending rock concerts show that most listeners sustain moderate TTSs, and recover within a few hours to a few days after exposure. However, Clark indicates that attendance at rock concerts remains an important contributor to the cumulative noise dose for many individuals.

Clearly, there is confusion about the relationship of exposure to loud music and hearing loss. It has been established that continued exposure to noise above 90 dB over time will cause permanent damage to hearing. The intermittent nature of music, combined with other factors such as sound level, duration, proximity, and frequency of listening make it virtually impossible to establish exposure limits and/or guidelines.

In conclusion, it is safe to assume that loud music can be dangerous to hearing. The results of this study indicate that subjects in all groups experienced temporary threshold shifts. The degree of threshold shift increased as exposure time increased. Further, 43% of the subjects reported tinnitus as a result of exposure. All recreational noise exposures must be considered as a summed whole when evaluating noise-induced hearing loss, so frequency of attendance at live music venues must be considered. Individuals who are frequently exposed to amplified music that exceeds safe levels over a long period of time are at substantial risk of developing noise-induced hearing loss. These results certainly have implications related to contemporary lifestyle issues. College students and other consumers must be educated about the risks associated with loud music exposure. Individuals who experience a ringing or buzzing in their ears or a muffling of sounds immediately after exposure to music should understand that the sound levels to which they were exposed were too loud. It is important to limit exposure time to loud music and whenever possible, turn down the volume. Appropriate hearing protection (ear plugs, musician plugs, etc.) should be used if exposures are frequent. A common sense approach is recommended.

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Table 1

Mean Threshold Shifts Across Frequencies for Subjects with ½ Hour Exposure

	500 Hz	**1000 Hz**	**2000 Hz**	**3000 Hz**	**4000 Hz**	**6000 Hz**	**8000 Hz**
Males ***n* = 5**	0 dB	0 dB	0 dB	.65 dB	1.14 dB	3.43 dB	0 dB
Females ***n* = 5**	0 dB	0 dB	.56 dB	.59 dB	1.01 dB	2.37 dB	0 dB
Group Mean	0 dB	0 dB	.28 dB	.62 dB	1.07 dB	2.90 dB	0 dB

Table 2

Mean Threshold Shifts Across Frequencies for Subjects with 1 Hour Exposure

	500 Hz	**1000 Hz**	**2000 Hz**	**3000 Hz**	**4000 Hz**	**6000 Hz**	**8000 Hz**
Males ***n* = 5**	0 dB	0 dB	.49 dB	1.45 dB	3.14 dB	4.06 dB	.63 dB
Females ***n* = 5**	0 dB	0 dB	.56 dB	1.69 dB	3.01 dB	3.23 dB	.54 dB
Group Mean	0 dB	0 dB	.77 dB	1.57 dB	3.07 dB	3.65 dB	.58 dB

Table 3

Mean Threshold Shifts Across Frequencies for Subjects with 1 ½ Hours Exposure

	500 Hz	**1000 Hz**	**2000 Hz**	**3000 Hz**	**4000 Hz**	**6000 Hz**	**8000 Hz**
Males ***n* = 5**	0 dB	0 dB	.79 dB	2.24 dB	3.34 dB	3.87 dB	.59 dB
Females ***n* = 5**	0 dB	.36 dB	.74 dB	1.89 dB	3.11 dB	4.03 dB	.64 dB
Group Mean	0 dB	.18 dB	.76 dB	2.06 dB	3.22 dB	3.95 dB	.61 dB

Table 4

Mean Threshold Shifts Across Frequencies for Subjects with 2 Hours Exposure

	500 Hz	**1000 Hz**	**2000 Hz**	**3000 Hz**	**4000 Hz**	**6000 Hz**	**8000 Hz**
Males ***n* = 5**	0 dB	.15 dB	.79 dB	2.65 dB	3.68 dB	4.26 dB	.75 dB
Females ***n* = 5**	0 dB	.35 dB	.85 dB	2.49 dB	3.55 dB	4.05 dB	.92 dB
Group Mean	0 dB	.25 dB	.82 dB	2.57 dB	3.62 dB	4.15 dB	.84 dB