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Does Earphone Type Affect Risk for Recreational Noise-induced Hearing Loss?

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Background

Over the past year, considerable media attention has been given to the potential risk of hearing loss associated with the use of portable music players. A study of output levels of portable compact disc (CD) players (Fligor and Cox, 2004) suggested recommendations for safer listening level and duration for consumers. Fligor and Cox (2004) also reported in-ear earphones produced higher sound levels than over-the-ear headphones at the same volume control setting. Based on this finding it was recommended that volume control settings and listening durations should be adjusted accordingly.

A report at this conference on output levels of mp3 players (Portnuff and Fligor) describes similar findings, updated for the current generation of technology.

We now know what portable music players and earphones of capable of, but how are these devices actually being used? This study describes how using different earphones in different background noise affected listening behavior. It also estimates the number of people who are potentially at risk for hearing loss from their portable music player headphones in different listening environments.

Methods

One hundred normal hearing doctoral students participated in a study of "chosen listening level" of music over earphones. Four different earphones styles were evaluated to see what affect they might have on students' listening behaviors: an over-the-ear Koss headphone KSC11, an in-the-ear Sony earphone MDREX51LP, an in-the-ear Etymotic Research ER-6i earphone, and the Apple iPod earbud.

Research subjects had their hearing tested to confirm normal hearing, and chose a song from a list of current popular titles. Two of the earphones in this study (Sony MDR-EX51LP and the ER-6i) were manufactured to provide some amount of background noise isolation, while the other two earphones (Koss KSC11 and the Apple iPod earbud) were not manufactured to block out background noise. The amount of background noise isolation each of the four earphones gave each research subject was measured.

The students were seated in an Audiology testing booth and different types of simulated and real-world noise conditions were played out through a speaker into the booth at different sound levels. The student was then signaled to turn on their music player and adjust the music to "where they like it". Those levels were recorded in the subjects' ear canal using a thin tube attached to a microphone, which fed the information out of the booth to a computer for recording. Some mathematical adjustments were made to the recordings to correct for the changes in level caused by the ear canal (this is so that levels can be directly compared to governmental noise limits established for loud sounds in the environment, such as factory noise filling a room).

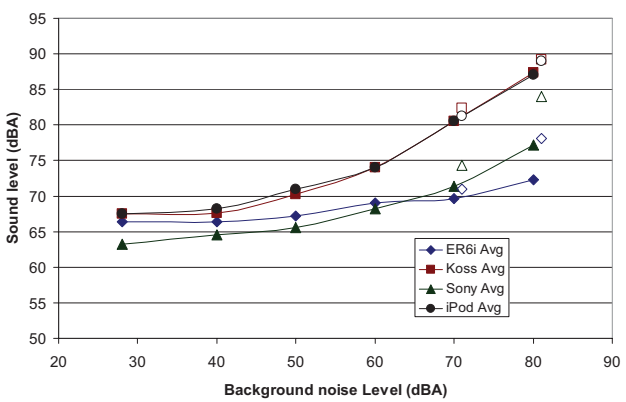

FIGURE 1. Average Chosen Listening Levels using the four different earphones in the various background noises. Filled symbols show chosen levels in pink noise, and open symbols show chosen levels in real-world noise conditions. The open symbols offset at 70 dBA background noise show listening levels in restaurant noise, and the open symbols offset at 80 dBA background noise show listening levels in airplane cabin noise.

This was repeated in random order for each earphone type, noise type, and noise level.

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Results

FIGURE 1 shows the average chosen listening levels for our subjects across the different background noise levels. The solid symbols show the chosen listening levels when subjects listened in an artificial noise ("pink" noise), and the unfilled symbols show listening levels in simulated real-life scenarios.

These real-world noises were recorded by the experimenters and replayed in the testing booth at the actual real-world measured levels.

Overall, students chose to listen to music at the same level when it was quiet (background noise less than 30 dBA). This was regardless of earphone type, since sound isolation in quiet was not an issue:

ER6i	Sony	Koss	iPod
66 dB	63 dB	67 dB	67 dB

TABLE 1. Average chosen listening levels with no additional background noise (so sound levels in the test booth were approximately 28 dBA).

Gender apparently matters: male subjects listened to music at levels significantly higher than female subjects (average chosen listening level in quiet was 5 dB higher in males than females, $p < 0.01$).

At the extreme opposite, when subjects listened in the noisy environment of a simulated airplane cabin (using actual airplane cabin noise recorded in coach class), striking differences were seen in the average chosen listening levels:

ER6i	Sony	Koss	iPod
78 dB	84 dB	89 dB	89 dB

TABLE 2. Average chosen listening levels with 80 dBA background airplane noise

For example, the difference between the chosen listening level of the ER6i and the iPod earbud was statistically significant ($p < 0.01$).

As expected, the four earphones provided different amounts of sound isolation, which should account for some of the differences seen in listening levels in the noisier conditions:

ER6i	Sony	Koss	iPod
25 dB	9 dB	2 dB	1 dB

TABLE 3. Average sound isolation provided by earphones

These data were analyzed by a nonlinear regression model to determine if the amount of sound isolation affected listening behaviors, and if this effect on behavior could be quantified.

As anticipated, chosen listening level in quiet was not affected by the type of earphone. Subjects do not listen louder with in-ear earphones than they do with over-the-ear headphones. The statistical analysis showed that the level of background noise had a large impact on chosen listening levels, and that a large number of people who listened at benign levels in quiet set the volume control to riskier levels in the noisier conditions, like the airplane cabin environment. This riskier behavior was ameliorated, though, when sound isolating earphones were used instead of earphones that did not block out background noise.

Discussion and Summary

While in-the-ear earphones can produce higher sound levels than over-the-ear earphones, they are not necessarily used at higher levels. Factors that affected chosen listening level were gender and the amount of background noise in the listening environment. Conversely, the amount of sound isolation provided by the earphones in noisy listening environments allowed subjects to choose music levels that were lower.

If a chosen listening level of 85 dBA is deemed the cut-off constituting "risky" behavior, then roughly 6% of subjects listening in a quiet setting are "risky listeners." What about the loud environment? We tested subjects in a common environment for using headphones (a "simulated" airplane cabin), and 80% of subjects using the Koss over-the-ear and iPod earbud earphones exceeded 85 dBA; these earphones provide essentially no sound isolation. When an ER-6i inthe- ear earphone was used (average of 25 dB sound isolation), only 20% exceeded 85 dBA.

This study estimates the number of people who listen in excess of "safe" levels, and the factors that influence a person to choose high sound levels. As well, it specifically describes the effect of sound isolating earphones in mitigating behaviors of listening to excessively high music levels. Findings from this study will provide consumers and healthcare providers with specific recommendations to reduce risk for music-induced hearing loss in users of mp3 players.

Fligor BJ & Ives TE (2006). Does headphone type affect risk for recreational noise-induced hearing loss? Paper presented at the NIHL in Children Meeting, Cincinnati, OH. Reprinted with permission.