ABSTRACT

PERCEIVED AND ACTUAL PERSONAL LISTENING DEVICE VOLUMES IN COLLEGE-AGE STUDENTS: IS EDUCATION ENOUGH?

by Kendrah T. Marchiondo

The purpose of the current study was to determine if personal listening device (PLD) users accurately report volume levels, if volume levels influence pure-tone thresholds, and if participants are aware of PLD potential for hearing damage. Hearing-health history, listening habits, level of hearing safety education, pure-tone thresholds, and dB SPL measures of PLD output volumes were collected for 180 participants. A standard ANOVA compared pure-tone thresholds to academic year, PLD usage hours, and dB SPL measures. SPL measures were converted to dB A for NIOSH comparisons. Researchers found 26 participants listened at harmful levels, increased usage time negatively influenced pure-tone thresholds (hours per week), subjects demonstrated awareness of PLD potential for hearing damage, and PLD users accurately reported volume levels, but did not demonstrate awareness regarding harmful volume levels. Results imply current hearing-health education methods should detail harmful volume levels, and NIOSH standards specific to music listening should be developed.
PERCEIVED AND ACTUAL PERSONAL LISTENING DEVICE VOLUMES IN COLLEGE-AGE STUDENTS: IS EDUCATION ENOUGH?

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Introduction

Over 12 million cases of adult hearing loss are believed to be caused, in part, by a combination of short-term and chronic exposure to loud noise (NIOSH, 1998). Multiple exposures to short-term loud noise are likely to evolve into long-term hearing deficits (Chung, Des Roches, Meunier, & Eavey, 2005). The prevalence of long-term hearing loss across all ages is rising; adults are experiencing permanent hearing loss at earlier ages and premature hearing loss is detectable in children and teens (Biassoni, et al., 2005; Daniel, 2007; McCormick & Matisitz, 2010; Niskar, et al., 2001; Serra, et al., 2005). Prevalence of noise induced hearing loss (NIHL) has increased from 14.9% to 19.5% since 1994 in U.S. adolescents between 13 and 19 years (Shargorodsky, Curhan, Curhan, & Eavey, 2010). Use of personal listening devices (PLDs) are considered a leading cause of noise-induced hearing loss (NIHL) (Biassoni, et al.; Chung, Des Roches, Meunier, & Eavey, 2005; Danhauer, et al., 2009; Fallon, 2010; McCormick & Matisitz; Niskar, et al.; Punch, Elfenbein, & James, 2011; Serra, et al.). The National Institute for Occupational Safety and Health (NIOSH, 1998) outlines safe levels of noise exposure for individuals in the workplace. The NIOSH recommended noise exposure limit (REL) is 85dB, A-weighted, as an 8-hr time weighted average. NIOSH recommendations for permissible exposure limits are based on a 3-dB exchange rate (increase or decrease in 3 dB corresponds to doubling or half the noise exposure dosage, respectively). For example, noise presented at levels of 115 dB for 15 minute periods exceed NIOSH REL (Daniel, 2007; Jones & Alarcon, 2009; NIOSH, 1998). Researchers discovered college students using PLDs are reaching hazardous levels at the City University of New York where 58.2% of student PLDs were set at listening levels greater than 85dB (Levey, Levey, & Fligor, 2011). Thus, output levels of PLDs have the potential to exceed NIOSH REL standards, which can lead to permanent hearing loss (Epstein, Marozeau, & Cleveland, 2010).

Although education in hearing loss prevention (i.e. wearing ear plugs to concerts, avoiding loud noise) is increasing in popularity, adolescents are still exhibiting poor listening behaviors (Shargorodsky, Curhan, Curhan, & Eavey, 2010). Poor listening behavior could stem from the delayed, incremental effects of long term hearing loss, resulting in decreased self-awareness until the effects are detectable at an older age. Only 8% of individuals between the ages 13 and 35 classify hearing loss as a “very big problem” (Chung, Des Roches, Meunier, & Eavey, 2005). Adolescents and young adults continue to underestimate warning signs of hearing loss (i.e. tinnitus, temporary hearing impairments, and fullness in the ear) following exposure to loud music, lacking concern for acute symptoms. Even when given information about NIHL, PLD users are not inclined to consistently modify poor-listening behaviors (Daniel, 2007; Shargorodsky, et al., 2010).

While the general population may understand the need for avoiding loud noise exposure, PLD users may be unaware that their devices have the potential to cause permanent, significant hearing loss due to decreased hearing health education (Epstein, Marozeau, & Cleveland, 2010). Presently, the only reported concern emerging from studies regarding PLD safety were distraction effects or reduced awareness of sirens when driving (Hoover & Krishnamurti, 2010). Listening to an iPod too loudly for just one afternoon may cause a temporary threshold shift, which PLD users do not associate with immediate loss of hair cells in the cochlea (Daniel, 2007; Punch, Elfenbein, & James, 2011; Shargorodsky, Curhan, Curhan, & Eavey, 2010). Decreased awareness of selected loudness levels, lengths of listening times, variability between music genres, and the potential for hearing loss can be a source for the increased incidence of adolescent hearing loss (Glorig, 1980; Jones & Alarcon, 2009; Shargorodsky, et al., 2010).
Researchers have utilized online survey methods to make similar conclusions from larger populations and to decrease costs by eliminating the need for expensive equipment and human subjects’ compensation (Chung, Des Roches, Meunier, & Eavey, 2005; Danhauer, et al., 2009; Hoover, 2010).

Other investigators clinically measure sound pressure levels (SPL) of a transducer in the ear to make conclusions regarding effects of PLD use (Epstein, Marozeau, & Cleveland, 2010; Levey, Levey, & Fligor, 2011). Although more costly than using a survey, measuring each transducer may be more reliable than self-reports due to the potential for decreased awareness and subject candor. Comparing self-report of listening volumes to SPL measurements in a controlled setting may determine the extent of self-monitoring integrity in PLD users. If self-report is found to be accurate and awareness is present, credibility for surveys reporting iPod listening habits may be validated (Epstein, et al., 2010; Danhauer, et al., 2009; Hoover, 2010). If self-report is inaccurate, the results may aid educators in developing programs to increase self-monitoring behaviors (Daniel, 2007).

The purpose of the present investigation is to determine if: 1) PLD users accurately report and self-monitor loudness levels, 2) volume levels of PLDs influence pure-tone thresholds, and 3) participants are aware of a PLD’s potential for hearing damage?

**Design and Methods**

**Participants**

Table 1 illustrates demographic information regarding the 129 females and 51 males (total, 180) with normal hearing recruited as participants (mean age = 19.8 years; range = 17-25 years). Subjects were recruited from the Miami University, Oxford Ohio area using scripted e-mails sent to listservs, advertisement fliers, and classroom announcements. All participants were screened for middle ear disease using otoscopy and tympanometry (Jerger, Burney, Mauldin, & Crump, 1974). The subject sample was considered representative of a typical Midwestern college.

**Instrumentation**

Informed consent was obtained prior to data collection. Participants were asked to bring their most frequently used PLD and headphones with them to testing. A standard set of iPod earbuds and a PLD was provided to 18 subjects who neglected to bring their own PLD. Upon arrival, subjects were given a health history questionnaire (Appendix A) to assess history of, or risk for, hearing loss due to reasons other than noise exposure. One participant was excluded due to self-reported smoking history.

Thresholds were measured with a diagnostic, clinical audiometer (Madsen, GSI 33) using the standard Hughson-Westlake method. Pulsed tones were presented through earphones (Telephonics, TDH-50P) mounted in supra-aural cushions (MX-51/AR) while participants sat in a double-walled sound booth (Industrial Acoustics Company). Annual calibration of the equipment was performed according to the American National Standards Institute (ANSI) guidelines (ANSI, 2004b). A listening check was performed daily on the equipment.

Following pure-tone testing, participants received a second listening habits survey (Appendix B) to investigate self-reported music listening patterns (i.e. hours per day/days per week of use, years of use, preferred music genres) and most frequently used device types (Danhauer, et al., 2009). Hours per day and days per week of reported PLD usage obtained from
the second survey allowed researchers to group subjects: rare users (< 2 hours per week), minimum users (≥ 2 and < 4.75 hours per week), moderate users (≥ 4.75 and < 7.5 hours per week), and extreme users (≥ 7.5 hours per week).

A Verifit VF-1 Audioscan was used to measure Sound Pressure Levels (SPLs) near the tympanic membrane of each participant. The Verifit VF-1 system was calibrated at the start of each week according to manufacturer specifications. A reference microphone, facing away from the participant’s shoulder for optimal performance, hung freely around the pinna and stopped at the base of the ear lobe. A probe microphone connected to the reference microphone was placed inside the participant’s ear canal after positioning at 28mm for females, and 30mm for males (Figure A) (Etymonic Design Incorporated, 2009).

First, an on-ear control run with the Verifit VF-1 established baseline data in dB SPL for each participant, without earbuds, in a quiet environment to ensure the probe microphone was not occluded or positioned incorrectly. The researcher placed the participant’s headphones over the probe microphone, instructed the participant to select the first of three favorite songs, and requested the participant adjust the volume to the most frequently used intensity level. As the selected song played, a 15-second live-voice speech spectrum map run provided dB SPL data in 1/3 octave intervals from 250 to 6K Hz. Measurements were taken for each of three songs selected by the participant to obtain a range of listening levels and music genres. Data was displayed on graphs and tables saved to a secure USB drive and reviewed at a later time. Values recorded were rounded to the nearest whole decibel by the equipment (Etymonic Design Incorporated, 2009).

Participants concluded testing with a third survey (Appendices C & D) investigating knowledge of potential risks for hearing loss related to PLD use. Items which queried self-awareness of listening volumes were addressed after all testing had been completed to reduce subject bias. A representational bar graph of the iPod volume bar (Appendix D) accompanied questions about typical, self-perceived listening volumes.

Test-retest measures were taken from 20 random participants using the same procedures, in-ear microphone, device, and headphones. Additionally, iPhone and iPod Nano baseline volume measurements from the Verifit VF-1 using white noise were taken at five points along the volume bar (Appendix D, Figure A) in the ear for 10 subjects (5 males, 5 females). Three different types of headphones (Skullcandy 2011 INK’D Blue/Black earbuds, The Apple Earphones, and Sony Earbuds MDR-E9LP Blue) were used with both devices. The results provided descriptive information about the differences between devices, earbud types, and individual ear canal response.

Descriptive statistics were performed on the data set using SAS Software Version 9.2 for Windows (SAS Institute Inc., 2008). The data were first summarized and examined for outliers and consistency. Several preparatory steps were taken to ready the data for analysis. Usage times were calculated by multiplying self-reported hours per day by days per week of PLD usage, pure-tone thresholds in dB HL were converted to SPL (ANSI S3.6 2004 American National Standard Specifications for Audiometers), and all samples of Verifit SPL values were converted to A-weighted equivalents for comparison to noise exposure standards. The Microphone in Real Ear technique (MIRE) (International Organization for Standardization, 2007) calibration tables were used to determine a coupler to free-field correction factor to report free-field equivalent levels for individual frequencies produced by the Verifit VF-1 (transfer function of the outer ear [TFOE] of the Verifit VF-1 measurements).
Individual pure-tone threshold levels averaged from both ears and 1/3 octave band SPL levels measured from the Verifit VF-1 for the frequencies 250 to 4000 Hz (SAS Institute Inc., 2008) were converted to Area Under the Curve (AUC) endpoints. AUC response profiles summarize the inherent capacity of a test for distinguishing a diseased from a non-diseased subject across potential levels of factor points into a single statistic and better reflect total output volume activity of the music waveform compared to traditional amplitude peaks (Liu & Li, 2005; Pynchon, Tucker, Ruth, Barrett, & Herr, 1998). The audiometric and Verifit VF-1 dB SPL data files were restructured to calculate the AUC per person, aggregated, and used as the dependent and independent variables in a standard ANOVA with pure-tone thresholds (dB SPL) as the dependent variable, and year in school, usage values of the PLD, and Verifit VF-1 dB SPL measures serving as independent variables. An additional Kruskal-Wallis Test to evaluate the relation between subjective report of harmful listening behavior and Verifit VF-1 AUC values was performed. Calculated RMS A-weighted values were compared to all the same variables as the AUC values in a second analysis. A value of $p < .05$ was set as the level of statistical significance for all tests reported.

**Results**

**Participant Information**

All 180 participants presented with pure-tone thresholds $< 25$ dB HL for octave frequencies from 250 to 8000 Hz, Type-A tympanograms, and no middle ear disease (Jerger, Burney, Mauldin, & Crump, 1974). Average threshold levels with standard deviations are shown in Table 2 for each academic year (freshman, sophomore, junior, senior). Examination of Table 2 shows mean thresholds and standard deviations (SD) to be fairly consistent across academic classes within the college-age population.

**Listening Habits**

Table 3 shows the means and ranges of the Verifit VF-1 SPL values and mean years of headphone use for 164 participants categorized by academic class. Sixteen subjects were excluded from the analysis for not fully responding to necessary survey questions.

Examination of the free-field, A-weighted equivalents in Table 3 reveal the differences between the maximum and minimum levels to be an average 11.49 dB higher than the dB SPL values. The average free-field corrected listening level was 72.98 dBA ($Range = 46.1 – 103.3; SD = 11.2$) for all subjects with a reported average of 6.93 hours of use per week ($SD = 9.51$ hours/week). A total of seven participants were found to listen at harmful levels when listening duration was taken into account. When examining the free-field equivalent values of individual frequencies within songs calculated using the MIRE method, sixteen subjects showed levels across 1-6 frequencies that were greater than or equal to 85 dB A in at least one song: 9 participants exhibited 1-2 Hz bands (range = 85-99 dB A), 3 participants exhibited 3-4 Hz bands (range = 85-89 dB A), and 4 subjects exhibited 5-6 Hz bands (range = 86-95 dB A) (Jones & Alarcon, 2009). Listening levels were similar across classes.

Subjective data investigating the frequency of listening at ‘harmful’ levels was classified into three categories: “yes”, “no”, or “at times” (Table 4). Ten of the 171 participants who responded to the question chose “yes”, fifty-five chose “no”, and 106 chose “at times”. Participants also reported frequency of noise exposure via headphones as follows: 53 subjects (30.1%) reported infrequent noise exposure (<2 hours/week) and 43 subjects (24.4%) reported
frequent exposure to noise (>7.5 hours/week). The results (Table 5) indicate that on average, participants in this study did not exceed the NIOSH REL for both the daily and weekly exposures (Jones & Alarcon, 2009).

Table 6 lists self-reported headphone types used by participants. Earbuds are more often used than over-the-ear types of headphones and non-noise cancelling headphones are more common than noise-cancelling headphones. Nine subjects reported more than one transducer type as “most often used”, accounting for the larger total report than the total number of subjects.

Verifit VF-1 SPL measures were calculated to assess output differences for two listening devices and three brands of headphones using white noise presented at five volume levels. Table 7 reports the midpoint and maximum levels estimated in dB A based on positioning of the volume bar related to different instrument and transducer types.

**Multivariate Analysis Results**

To quantify the significance of music exposure listening habits on pure-tone threshold levels, a three-way analysis of variance (ANOVA) was performed using threshold as the dependent variable with years of earbud use, reported daily usage levels and dB SPL output as factors. Tables 2 and 3 demonstrate the similarity of hearing levels and listening levels among academic classes. The AUC dB SPL response profile converted from the Verifit VF-1 probe-microphone listening levels did not detrimentally worsen participants’ threshold levels, $F(2, 172) = 1.54, p = 0.12$. Furthermore, the AUC pure-tone thresholds were the same for the participants who reported a long history of earbud use versus those who did not, $F(3, 160) = -0.60, p = 0.55$. Significant differences were found in the pure-tone thresholds based on report of weekly usage times indicating those who reported longer weekly usage times had significantly worse pure-tone hearing across the audiometric frequencies, $F(2, 172) = 2.22, p = 0.03$. Furthermore, reliability coefficients for test-retest reliability were high ($r = 0.78, p < .001$) for 21 subjects who returned for a second measurement series.

A multivariate analysis comparing participants’ Verifit VF-1 dB SPL values to subjects’ reported typical loudness levels to evaluate reported information consistency with real-ear sound measurements was conducted. Analyses show no consistency between measured SPLs and reported loudness levels; $F(4, 166) = .14, p = .97$. However, when calculated dB A weighted values were compared to reported typical loudness levels, results indicated accurate perception of selected volume levels occurred; $F(4, 166) = 34.02, p = .0001$. Comparison of participants’ dB A loudness levels to reported occurrence of harmful levels indicated participants are likely to be aware of listening (or of not listening) at harmful volumes; $F(2, 168) = 4.45, p = .01$.

Analysis of PLD volume levels by earphone type using white noise stimuli indicated no significant differences in output volumes between the iPhone and the iPod Nano devices when using the same headphones (Table 7). However, between different brands of headphones using the same device, significant differences were noted ($p = .004$).

**Discussion**

The American Medical Association has published warnings against excessive noise exposure since 1956 and now recognizes the importance of promoting healthy listening behavior with the use of in-ear headphones (Glorig, Wheeler, & House, 1956; McCaffree, 2008). The possibility of increased incidence of hearing loss due to PLD use has been popularized in recent media stories. More recently, college students, in general, were found to listen with their PLDs in excess of safe listening levels and use PLDs longer (Levey, Levey, & Fligor, 2011). The
number of this at-risk younger group of listeners has been a popular topic of discussion (Fligor, 2009; Danhauer et al., 2009; Torre, 2008; Daniel, 2007; Epstein, Marozeau, & Cleveland, 2010; Hoover & Krishnamurti, 2010; McCaffree, 2008; McCormick & Matisitz, 2010). Differences in methodology, sound level calibration systems, choice of stimuli and transformation of data hinder accurate representation of an individual’s habitual listening behavior as compared to NIOSH and OSHA standards. Remarkable intra-subject reliability of the Verifit VF-1 measurements were found upon retesting 20 subjects ($r = .78$).

Similar studies report differences between intensity levels by music genres, emphasizing the importance of individual listening preferences in experimental investigations (Jones & Alarcon, 2009; Worthington et al., 2009). In the current study, subjects were also instructed to adjust the volume to a typical listening level to reduce tester bias towards higher or lower listening levels. College-aged student perception of PLD listening level becomes important because of the potential for hearing loss years later. In the current study average free-field equivalent Verifit VF-1 value for participants across a typical day was 72.98 dB A. Twenty-six participants demonstrated intensity levels greater than 85 dB A. Only seven of this set were listening at durations exceeding the RELs outlined by NIOSH. Epstein and colleagues (2010) also found few subjects were listening at harmful levels and durations.

The alarm associated with the recent generation of PLDs (e.g. iPods) is justified when considering the length of time one can listen to music coupled with improved sound quality. Of more concern is that the rate of PLD use is increasing dramatically (Ahmed, et al.; Torre, 2008; Williams, 2005). Of the headphones selected, all three transducers exceed NIOSH recommended levels at or slightly above the halfway mark on the volume bar of the iPod devices selected for testing (Table 7). However, even though devices and transducers have the potential to exceed current standards and play at harmful levels, most participants in the current study are not listening at harmful levels or for lengthy durations (NIOSH, 1998).

Risk for NIHL is not as simple as a chosen listening level, however, because individual use over time dictates risk (Fligor & Meinke, 2009). Individual usage time and diffuse-field equivalency were accounted for in the current study to estimate risk for NIHL. Diffuse-field estimates and usage times (Tables 3 and 6 respectively) were based on standards-based measurement methods and self-reported duration of use. Seven participants were found to be at risk for occupational noise exposure when listening in a quiet environment. Similar reported weekly usage times were found by Worthington et al. (2009) in a convenience sample of 23 students from a similar subject pool. Our results suggest that listeners who use their PLD for more hours in a week exhibit statistically significant decrements in hearing. However, even subjects whose listening volumes exceeded 90 dB SPL reported listening times at less than 30 minutes per day for little risk (Jones & Alarcon, 2009; NIOSH, 1998). Regardless, at least twenty-six subjects were found to listen at levels louder than 85 dB A. Given longer usage times their risk for NIHL would increase.

Current definitions of “harmful listening” levels for music listening as designated by OSHA and NIOSH standards are not clearly outlined (Jones & Alarcon, 2009; NIOSH, 1998). The results of the current study indicate there is a differential effect of weekly usage time on pure-tone thresholds 500 to 8000 Hz. Yet, the effect noted in the current research may not be solely attributed to PLD usage. According to Fligor & Meinke, 2009, NIHL may be due to difficult-to-measure additional variables such as stereo system use or incidence of noise exposure in recreational environments. Yet, Kumar et al., 2009 found small elevations in pure-tone thresholds among 70 young adults who used PLDs for at least two years (Kumar et al., 2009).
NIOSH (1998) standards are based on OSHA (1983) guidelines designed to define a threshold of ‘harmful levels’ and durations for the adult workforce. The current research found a significant trend for usage time in the targeted population for hearing loss, however the selected participants were not listening at currently defined “harmful levels”. Perhaps the use of an 85 dBA criteria may make assumptions that are not applicable to a younger population. Similarly, OSHA and NIOSH recommendations were implemented for 10-40 years of exposure periods (Fligor & Meinke, 2009; NIOSH, 1998). In the current sample, young adults had already been using PLDs regularly for 7 to 8 years. Modern youth are beginning and increasing usage earlier in life and potentially listening for more years. (Ahmed, et al.; Torre, 2008; Williams, 2005). Additional NIOSH standards specific to music listening may need to be outlined to compensate for changes in popular culture.

Measured variability between earphone styles on output, as well as the impact of the individual’s ear canal also contributes to differences in SPL output across headphone brands (Table 7). That is, although one device may have a consistent output, it can become potentially harmful based on the transducer it is coupled with. Significant differences in output volumes were found between all transducers regardless of device in males ($p < .01$). Of the three headphone brands tested, the iPod earbuds were found to be the quietest, albeit very minimally. Sony and Skullcandy earbuds had the loudest maximum output capacity. All brands of earbuds have the potential for exceeding NIOSH standards, depending on listening duration and selected volume level. Measurements in the current study may have been affected by the differences in transducer outputs, although it can be argued that participants would perceive the difference across headphones and adjust the volumes accordingly.

Table 7 illustrates the similarity of listening levels between gender ($p = .75$), consistent with Levey et al. (2011). However, due to the large difference in sample size between males (52) and females (127) in the current study, such results are inconclusive. Students in the current study reported a variety of listening environments that may include background noise which they believed influenced their volume levels. Students simulated such volume levels in the testing room. The range of environments reported included, but were not limited to: when walking to class, when riding a bus, when studying, when exercising, and when doing yard work or working. Kumar et al. (2009) found no effect of background noise in determining PLD listening level, although other researchers report that young people may use higher volume settings with louder background noise (Fligor & Ives, 2006; Portnuff, Fligor and Arehart, 2009; Worthington et al., 2009). Further study should include specific types of background noise that can be generalized to all listening situations.

In the exit interview, 31% of participants were certain that they were not using their PLDs at harmful levels and 96% were correct in their assumptions (53 of the 55 reporting no). Ten participants (6%) believed they were using their device at harmful levels; however, only, 1 of the 10 was correct in the belief. Trends in the multivariate analysis suggest participants were accurate in reporting frequency of harmful listening. While participants who said “yes” were more likely to be incorrect, participants who said “no” or “at times” were generally accurate. However, the frequency count analysis did not take duration of listening times into account, only dBA values greater than 85. Thus, the current study is unable to conclude the credibility of participant responses regarding self-report of “frequency of harmful listening”. Failure to accurately report listening levels indicates using survey methods of data collection to make conclusions about such information may be inaccurate.
The exit interview also found that 152 participants would reduce their listening level or shorten duration if given information by audiologists or doctors, indicating participants are aware of the potential for hearing loss due to PLDs. Since participants were likely to have awareness of their listening level, but were unlikely to know if such a level was harmful or not, further explicit education detailing at what point along the volume bar is “too harmful” for consumers may be beneficial. Such standards may need to be outlined differently based on each brand of headphones to account for differences noted in this study (Table 7). For the 180 current participants, all enrolled in higher education, public awareness and information could play an important role in preventing loss due to over exposure from music delivered not only by their PLD, but computer, car, or music stereo. Technology interventions might address risk for NIHL by monitoring (or minimizing) the integration of sound level with usage times.

Current results suggest present hearing health education is providing effective cautionary measures as evidenced by the low number of participants (twenty-six) that exceeded 85 dB A. All subjects reported that loud sounds can damage hearing acuity, even those (6%) who also reported no prior education regarding the risks of hearing loss from loud sounds. No subjects reported the belief that devices are manufactured with output limits, providing a safety mechanism for harmful levels.

Limitations of the current study include the fact that much of the usage estimates relied on the study participants’ accurate report of their duration of PLD use. Use of three song levels measured in the ear and subjected to MIRE conversions should provide a representative sample of listening level (Berger, Megerson, & Stergar, 2009). However, if participants are inaccurate when self-reporting intensity levels, then they could also be inaccurate when reporting duration levels. If this is the case, participants who have been measured with > 85 dB A peak levels within songs may be in danger of damaging their hearing over time. Much research on the topic has relied on participant self-report (Worthington et al., 2009; Williams, 2005) and, in the absence of technical solutions to monitor participants’ duration of use, self-report is the most effective method for estimating use in a large number of participants (Griffin, Netizel, Daniell, & Seixas, 2009). If exposure to NIHL-prevention programs were to decrease or change, individual habits may change and cause a subsequent shift in risk for hearing loss.
References


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Appendix A

History Questionnaire

Subject ID#: _____________ Date: _____________ Tester Initials: ______

Subject Demographics:
Age: ________
Sex: ________
Grade Level/Academic Year: ______

Hearing History:
1. Do you have any concerns with your hearing? If yes, please elaborate:
2. Do you listen to music?
3. Have you had a history of ear infections? If yes, please elaborate:
4. Have you ever been exposed to loud noises? If so, in what environment(s)?
5. Do you wear hearing protection when in noise?
6. How often do you wear hearing protection? Please list in what situations:
7. Are you on any medications (Aspirin, etc.) that might influence your hearing? If yes, please list:
8. Have you experienced any ringing in your ears (past or present)? If yes, please explain:
9. Have you had any head or neck injuries or surgeries within the last year? If yes, please explain:
10. Do you have a family history of hearing loss? If yes, please explain:
11. When not using speakers to listen to music, what type of headphones do you use most often?
   - Earbuds
   - Over-the-ear
   - Noise cancelling
   - Other
Appendix B

Subject ID#:_____________   Date:______________   Tester Initials:_______

1. What is the name of the listening device you currently use majority of the time?
   - iPod Classic
   - iPod Shuffle
   - iPod Nano
   - iTouch
   - iPhone
   - Zune
   - Other:____________

2. How long have you been using this particular listening device?

3. On average, how many days per week do you use your device with headphones?
   ___________ days/week

4. On average, for how many hours per day do you use your device with headphones?
   ___________ hours/day

5. In what situation do you listen to the device under headphones the majority of the time?
   - Home
   - Bus
   - Walking to class
   - While exercising
   - When studying
   - Other:____________

6. Do you listen with headphones more often than with speakers?

7. With which devices do you use to listen to music through speakers? Check all that apply:
   - Computer
   - Speakers
   - Stereo system
   - iHome/dock
   - Other____________
   - I do not use speakers

8. Have you previously owned any of the following Portable Listening Devices (PLDs)? Check all that apply:
   - Personal cassette player
   - Portable compact disk
   - Personal AM/FM radio
9. What genres of music do you generally listen to a majority of the time under headphones? Check all that apply.

- [ ] Pop/Rock
- [ ] R&B/Hip-Hop
- [ ] Alternative
- [ ] Metal
- [ ] Country
- [ ] Other: ________________________
Appendix C

Subject ID#:______________  Date:______________  Tester Initials:______

1. At what sound level do you typically keep your listening device for comfortable listening? Reference Figure A on the laminated sheet and select a number rating:
   a. 1
   b. 2
   c. 3
   d. 4
   e. 5

2. Can loud sounds cause damage to your hearing?
   a. Yes
   b. No

3. What volume level do you feel is the beginning point for “too loud” that will begin to harm your hearing? Please reference figure B on the laminated sheet and select a number rating:
   a. 1
   b. 2
   c. 3
   d. 4
   e. 5
   f. 6

4. What length of listening time with earbud headphones (in one sitting) do you feel is “too long” and will begin to harm your hearing?
   a. 30 minutes
   b. 1 hour
   c. 2 hours
   d. 3 hours

5. Do you feel that you listen to your device at harmful levels?
   a. Yes
   b. No
   c. At Times

6. If you learned that you were listening to your device at harmful levels, would you turn it down/limit your daily use?
7. From which of these persons would you be most likely to follow advice given, regarding iPod/earbud use and hearing loss?
   a. Doctors
   b. Audiologists
   c. Manufacturers
   d. Celebrities
   e. Family
   f. Friends

8. Would you like more information regarding iPod/earbud use and potential hearing loss?
   a. Yes
   b. No
None of the above – even the maximum volume on personal listening devices are safe because manufacturers make sure they are.
### Table #1
Sex and Age with Standard Deviation (SD) by Academic Class

<table>
<thead>
<tr>
<th>Academic Class</th>
<th># Males</th>
<th># Females</th>
<th># Total</th>
<th>Mean Age (yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td># Freshman</td>
<td>18</td>
<td>26</td>
<td>44</td>
<td>18.2</td>
</tr>
<tr>
<td># Sophomores</td>
<td>8</td>
<td>39</td>
<td>47</td>
<td>19</td>
</tr>
<tr>
<td># Juniors</td>
<td>8</td>
<td>32</td>
<td>40</td>
<td>20.1</td>
</tr>
<tr>
<td># Seniors</td>
<td>17</td>
<td>32</td>
<td>49</td>
<td>21.2</td>
</tr>
<tr>
<td># Total</td>
<td>51</td>
<td>129</td>
<td>180</td>
<td>19.8</td>
</tr>
<tr>
<td>SD Age (yr)</td>
<td>21.5 ± 3.5</td>
<td>20.5 ± 2.5</td>
<td>21 ± 4</td>
<td>19.7 ± 1.5</td>
</tr>
</tbody>
</table>

### Table #2
Means and SD of Pure-tone Thresholds (dB HL) by Academic Class

<table>
<thead>
<tr>
<th>dBHL</th>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>9.04 ± 5.31</td>
<td>9.06 ± 5.80</td>
<td>9.12 ± 5.87</td>
<td>9.87 ± 6.83</td>
</tr>
<tr>
<td>500</td>
<td>6.22 ± 4.24</td>
<td>4.95 ± 4.59</td>
<td>4.17 ± 4.74</td>
<td>2.86 ± 4.67</td>
</tr>
<tr>
<td>1000</td>
<td>4.07 ± 4.47</td>
<td>3.91 ± 4.02</td>
<td>3.57 ± 4.17</td>
<td>1.89 ± 3.94</td>
</tr>
<tr>
<td>2000</td>
<td>2.73 ± 5.02</td>
<td>1.67 ± 4.33</td>
<td>2.86 ± 4.74</td>
<td>0.92 ± 4.67</td>
</tr>
<tr>
<td>4000</td>
<td>3.66 ± 5.33</td>
<td>4.38 ± 5.91</td>
<td>3.33 ± 5.32</td>
<td>2.91 ± 5.91</td>
</tr>
<tr>
<td>8000</td>
<td>10.23 ± 6.75</td>
<td>10.99 ± 7.66</td>
<td>9.76 ± 6.96</td>
<td>10.41 ± 6.91</td>
</tr>
<tr>
<td>Mean 2kHz, 4kHz, and 8kHz</td>
<td>5.54 ± 3.80</td>
<td>5.68 ± 3.87</td>
<td>5.32 ± 4.06</td>
<td>4.74 ± 4.38</td>
</tr>
<tr>
<td>Mean Wideband (250Hz – 8kHz)</td>
<td>6.01 ± 2.99</td>
<td>5.83 ± 2.95</td>
<td>5.64 ± 3.51</td>
<td>4.48 ± 3.43</td>
</tr>
</tbody>
</table>
### Table #3

**Verifit Means in dB SPL and dB A, and Years of Use**

<table>
<thead>
<tr>
<th>Academic Year:</th>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
</tr>
</thead>
<tbody>
<tr>
<td>dB SPL Means and SD:</td>
<td>61.08 ± 12.57</td>
<td>62.31 ± 12.29</td>
<td>61.50 ± 10.91</td>
<td>61.07 ± 10.91</td>
</tr>
<tr>
<td>dB A Means and SD:</td>
<td>72.42 ± 12.30</td>
<td>73.88 ± 11.93</td>
<td>73.17 ± 10.19</td>
<td>72.44 ± 10.48</td>
</tr>
<tr>
<td>Years of headphone use:</td>
<td>7.52 ± 3.30</td>
<td>9.00 ± 3.08</td>
<td>8.49 ± 2.90</td>
<td>8.17 ± 3.48</td>
</tr>
</tbody>
</table>

### Table #4

**Perceived Listening at “Harmful” Levels of 171 Participants**

<table>
<thead>
<tr>
<th>Self-Report</th>
<th># Participants</th>
<th>Mean dB A</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>10</td>
<td>78.9</td>
<td>12.8</td>
</tr>
<tr>
<td>At Times</td>
<td>106</td>
<td>74.3</td>
<td>10.6</td>
</tr>
<tr>
<td>No</td>
<td>55</td>
<td>69.9</td>
<td>11.5</td>
</tr>
</tbody>
</table>
**Table #5**  
*Subjective Weekly Usage of 176 Participants*  

<table>
<thead>
<tr>
<th>Hours/Week</th>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2.000</td>
<td>23.26%</td>
<td>21.28%</td>
<td>43.59%</td>
<td>34.04%</td>
</tr>
<tr>
<td>≥ 2.000, &lt; 4.75</td>
<td>25.58%</td>
<td>14.89%</td>
<td>17.95%</td>
<td>12.77%</td>
</tr>
<tr>
<td>≥ 4.75, &lt; 7.50</td>
<td>23.26%</td>
<td>31.91%</td>
<td>23.08%</td>
<td>31.91%</td>
</tr>
<tr>
<td>≥ 7.50</td>
<td>27.91%</td>
<td>31.91%</td>
<td>15.38%</td>
<td>21.28%</td>
</tr>
</tbody>
</table>

Average incidence with SD in hrs/week:  

<table>
<thead>
<tr>
<th></th>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.20 ± 11.52</td>
<td>6.96 ± 5.29</td>
<td>4.77 ± 5.90</td>
<td>7.56 ± 12.90</td>
</tr>
</tbody>
</table>

**Table #6**  
*Types of Headphones*  

<table>
<thead>
<tr>
<th>Headphones</th>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular (R)</td>
<td>Noise-Cancelling (NC)</td>
<td>R</td>
<td>NC</td>
<td>R</td>
<td>NC</td>
</tr>
<tr>
<td>Earbuds</td>
<td>38</td>
<td>1</td>
<td>47</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>Over-the-Ear</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Totals</td>
<td>42</td>
<td>2</td>
<td>51</td>
<td>3</td>
<td>36</td>
</tr>
</tbody>
</table>

**Table #7**  
*White Noise Data dB A*  

<table>
<thead>
<tr>
<th>Device</th>
<th>Headphones</th>
<th>Means &amp; SD Midpoint Volume (Females)</th>
<th>Means &amp; SD Midpoint Volume (Males)</th>
<th>Means &amp; SD Maximum Volume (Females)</th>
<th>Means &amp; SD Maximum Volume (Males)</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPhone</td>
<td>Sony</td>
<td>82.2 ± 5.8</td>
<td>82.8 ± 5.3</td>
<td>112.9 ± 4.2</td>
<td>113.3 ± 5.3</td>
</tr>
<tr>
<td></td>
<td>Skullcandy</td>
<td>84.3 ± 4.1</td>
<td>88.5 ± 4.1</td>
<td>115.1 ± 2.2</td>
<td>117.4 ± 3.0</td>
</tr>
<tr>
<td>iPod</td>
<td>78.6 ± 4.6</td>
<td>74.7 ± 7.0</td>
<td>108.2 ± 3.9</td>
<td>106.2 ± 3.7</td>
<td></td>
</tr>
<tr>
<td>Nano</td>
<td>Sony</td>
<td>79.5 ± 1.3</td>
<td>78.5 ± 3.5</td>
<td>111.4 ± 2.7</td>
<td>112.0 ± 3.1</td>
</tr>
<tr>
<td></td>
<td>Skullcandy</td>
<td>83.8 ± 2.7</td>
<td>85.0 ± 4.1</td>
<td>116.5 ± 3.3</td>
<td>116.1 ± 4.1</td>
</tr>
<tr>
<td></td>
<td>iPod</td>
<td>79.3 ± 6.8</td>
<td>74.2 ± 1.6</td>
<td>108.3 ± 3.5</td>
<td>105.1 ± 2.4</td>
</tr>
</tbody>
</table>
*Instead of the transducer + foam tip, the iPod earbud is inserted*