Perceived and Actual PLD Listening Volumes in College-Age Students: Is education enough?

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Many researchers believe that PLD use with headphones may be causing the increased incidence in hearing loss among current adolescents.

Proposed due to decreased awareness regarding the potential for PLDs to cause hearing loss (Chung, Des Roches, Meunier, & Eavey, 2005; Epstein, Maraozeau, & Cleveland, 2010; Shargorodky, et al., 2010).

Researchers have taken direct measurements or used surveys to make conclusions regarding these hypotheses in the past. (Chung, Des Roches, Meunier, & Eavey, 2005; Danhauer, et al., 2009; Hoover, 2010).
The purpose 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 PLD potential for hearing damage.
Participants

• 178 participants (127 females and 49 males)
  • Range: 17 – 23 years; mean age: 19.8 years
  • Scripted e-mails, fliers, & classroom announcements

• Groups:
  • Academic class, gender, & hours/week of listening

• All were screened for middle ear disease using otoscopy and tympanometry (Jerger, Burney, Mauldin, & Crump, 1974).

• Sample considered representative of a typical Midwestern college.

• The Committee for the Use of Human Subjects in Research at Miami University approved this study. All subjects sign informed consent agreements and are compensated ($20) for their time.
**Instrumentation**

- **Questionnaires**
  - Health History
  - Listening Habits
    - Usage groups
    - Knowledge Base
- **Audiometric Data**
  - Otoscopy/Tympanometry
  - Pure Tone testing
  - Verifit VF-1 Audioscan Measures
    - iPod testing
    - Reliability & white noise data
Statistical Analysis

• Descriptive Statistics:
  • Pure tone thresholds in dB HL were converted to SPL for analysis purposes.

• Multiway-analysis of variance:
  • Dependent Variable: Pure tone thresholds
  • Independent variables: Year in school, usage values of the PLD, and dB SPL from Verifit VF-1

• Kruskal-Wallis:
  • Independent variables: subjective report of harmful listening intensity
  • Dependent variable: Verifit VF-1 measures
Readying the Data for Analysis

- Usage time calculated into hours per week
- Verifit SPL values were converted to A-weighted equivalents for comparison to noise exposure standards.
  - MIRE technique
Readying the Data for Analysis

• Pure tone threshold levels averaged from both ears (dBA) were converted to Area Under the Curve (AUC) endpoints.

• AUC measures better reflect total output volume activity of the music waveform, as traditional amplitude peaks may not adequately describe the frequency peak-to-peak changes (Pynchon, Tucker, Ruth, Barrett, & Herr, 1998).
Descriptive Results (Pure tone)

• Pure-tone:
  • Pure-tone thresholds at \( \leq 25 \) dB HL for octave frequencies (250 to 8000 Hz), Type-A tympanograms, and no middle ear disease.
  • Mean thresholds & standard deviations (SD) fairly consistent across academic class.
Descriptive Results (Verifit)

- **Original dBSPL:**
  - 16 (5 males, 11 females) **subjects** listened to at least 1 song at an average greater than or equal to 80dB SPL.
    - 7 of the 16 subjects’ song levels exceeded 85 dB SPL.
    - 11 of the 16 subjects’ song levels have 1-4 frequencies with dB SPL measures reaching harmful levels (≥85dB SPL) in 1-3 songs per subject.
    - 9 subjects with “safe” averages have 1-4 frequencies reaching harmful levels in 1-2 songs per subject.

- **MIRE conversion from dBSPL to dBA:**
  - Average free-field corrected level (MIRE) was 56.9 dBA (Range = 25.9-86.1; SD = 14.7)
    - With a reported average of 6.93 hours of use per week (SD = 9.51).
    - A-weighted equivalents averaged 4.6 dB lower than SPL values measured in the ear canal.
    - 8 subjects had at least 1 song that exceeded 80 dBA.
    - 2 of the 8 exceeded 85 dBA.
Descriptive Statistics (Subjective Report)

- “Harmful listening” report:
  - 11 (6%) subjects = yes
    - 1 was correct
  - 55 (31%) subjects = no
    - 53 (96%) were correct
  - 106 subjects = at times

- Noise exposure:
  - 53 subjects (30.1%) = infrequent noise exposure (<2 hours/week)
  - 43 subjects (24.4%) = frequent exposure to noise (>7.5 hours/week)

- Reports of listening durations (hours/week) do not exceed NIOSH REL.

- Earbuds are more often used than over-the-ear types of headphones
  - Noise-cancelling headphones are less common than non-noise cancelling headphones.
  - iPod (75), Sony (16), & Skullcandy (15) were the 3 most popular types of headphones.
Multivariate Analysis Results

• Thresholds & listening levels → similar across academic class.
• The AUC conversions did not significantly change thresholds
  • $F(3, 160) = 1.05, p = 0.29$
• AUC pure-tone thresholds → same regardless of years of use
  • $F (3, 160) = -0.60, p = 0.55$
• Longer weekly usage time reported → significantly worse pure-tone thresholds
  • $F(3, 160) = 2.32, p = 0.02$
• Self-report of average volumes → not consistent with Verifit VF-1 dB SPL values
  • $F (4, 166) = .14, p = .97.$
Discussion

• Our results suggest listeners who use PLDs for more hours in a week have worse pure-tone thresholds.
  • Subjects exceeding 90 dB SPL reported listening for less than 30 minutes per day, which does not exceed NIOSH REL because risk for NIHL takes into account listening level and duration of exposure (Fligor & Meinke, 2009; Jones & Alarcon, 2009; NIOSH, 1998).

• Thus, none of our listeners exceeded NIOSH RELs.
  • Only 7% of the participants exceeded 85 dB SPL in one or more or their song selections.

• Potential for transducer to exceed harmful levels (white-noise).
• Regardless of potential, participants in this study are not listening at harmful levels (in a quiet setting) or for harmful durations.
White-Noise Averages (Males)

<table>
<thead>
<tr>
<th>Earbud Type and Device</th>
<th>12.5% Volume</th>
<th>25% Volume</th>
<th>50% Volume</th>
<th>75% Volume</th>
<th>100% Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sony Earbuds iPhone</td>
<td>50.61</td>
<td>56.06</td>
<td>70.44</td>
<td>83.17</td>
<td>100.89</td>
</tr>
<tr>
<td>Skullcandy Earbuds iPhone</td>
<td>52.89</td>
<td>61.94</td>
<td>71.28</td>
<td>84.33</td>
<td>102.00</td>
</tr>
<tr>
<td>iPod Earbuds iPhone</td>
<td>44.83</td>
<td>49.78</td>
<td>59.78</td>
<td>74.39</td>
<td>93.72</td>
</tr>
<tr>
<td>Sony Earbuds iPod Nano</td>
<td>44.83</td>
<td>52.72</td>
<td>64.61</td>
<td>77.78</td>
<td>99.44</td>
</tr>
<tr>
<td>Skullcandy Earbuds iPod Nano</td>
<td>47.72</td>
<td>56.28</td>
<td>69.61</td>
<td>83.33</td>
<td>101.00</td>
</tr>
<tr>
<td>iPod Earbuds iPod Nano</td>
<td>40.67</td>
<td>44.89</td>
<td>59.22</td>
<td>73.06</td>
<td>92.11</td>
</tr>
</tbody>
</table>
Discussion Cont’d

• NIOSH standards are based on OSHA guidelines designed to define a threshold of ‘harmful levels’ and durations for the adult workforce and are not clearly defined for music listening:
  • We found a trend 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).
  • Increased total years of exposure?
  • Coupled with occupational & environmental noise exposure?

• NIOSH standards may need to be revamped to compensate for changes in popular culture.
Conclusion

• Cautious listening!
  • 68% think they listen at loud levels (sometimes/always).
• Heed warnings.
  • Population sample effects?
• 100% of subjects reported loud sounds can damage hearing acuity.
  • 6% also reported no previous hearing safety education.
• Parental influence?
• Current media influence?
• Public awareness and information could play an important role in preventing hearing loss from all sources of overexposure to music.
• Technology interventions might address risk for NIHL.
• Present levels and methods of hearing safety education should continue in order to maintain, if not increase, the incidence of consumers that monitor their listening habits.
References


References Cont’d


Liu, & Li. (2005). Testing statistical significance of the area under a receiving operating characteristics curve for repeated measures design with bootstrapping. Journal of Data Science 3, 257-278.


