Assessing MP3 Player Use in the Clinic: Measurement and Counseling

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Noise (& Music)-Induced Hearing Loss

Damage risk criteria (DRC):
- Function of time of exposure and the level (dBA) of the exposure ( = “Noise Dose” or “TWA”)
- “Acceptable” risk is a judgment call

Population Fractiles of susceptibility:

<table>
<thead>
<tr>
<th>0.1</th>
<th>0.5</th>
<th>0.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fragile</td>
<td>Avg</td>
<td>Tough</td>
</tr>
<tr>
<td>(10% most)</td>
<td></td>
<td>(10% least)</td>
</tr>
</tbody>
</table>

Damage Risk Criteria

- NIOSH
  - 85 dBA | 8 hrs
  - 88 dBA | 4 hrs
  - 91 dBA | 2 hrs
  - 94 dBA | 1 hr

- OSHA
  - 90 dBA | 8 hrs
  - 95 dBA | 4 hrs
  - 100 dBA | 2 hrs
  - 105 dBA | 1 hr

- WHO
  - 80 dBA | 8 hrs
  - 83 dBA | 4 hrs
  - 86 dBA | 2 hrs
  - 89 dBA | 1 hr

LIBERAL ........................................... CONSERVATIVE
OSHA (1981):
Minimum Standard for Safety

<table>
<thead>
<tr>
<th>Organization</th>
<th>TWA Noise Exposure</th>
<th>Estimated % at Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO</td>
<td>90 dBA</td>
<td>21%</td>
</tr>
<tr>
<td></td>
<td>85 dBA</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>80 dBA</td>
<td>0%</td>
</tr>
<tr>
<td>EPA</td>
<td>90 dBA</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>85 dBA</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>80 dBA</td>
<td>5%</td>
</tr>
<tr>
<td>NIOSH</td>
<td>90 dBA</td>
<td>29%</td>
</tr>
<tr>
<td></td>
<td>85 dBA</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>80 dBA</td>
<td>3%</td>
</tr>
<tr>
<td>Prince, et al 1997</td>
<td>85 dBA</td>
<td>8%</td>
</tr>
</tbody>
</table>

EPA
- 90 dBA 22%
- 85 dBA 12%
- 80 dBA 5%

NIOSH
- 90 dBA 29%
- 85 dBA 15%
- 80 dBA 3%

So… what criteria do we use?

- Damage-risk Criteria
  - 90 dBA, 5 dB exchange ratio (OSHA)
  - 85 dBA, 3 dB exchange ratio (NIOSH)
  - 80 dBA, 3 dB exchange ratio (WHO)

- Percentage of noise dose due to music?
  - 50%
  - 100%
  - Some other percentage?

Who is at risk for MIHL

- Musicians
  - Amplified musicians
    - Stage levels can exceed 110 dBA
  - Classical musicians
    - Levels may be lower, but exposure time is greater
- Music students
  - Long exposure time
Who is at risk for MIHL?

- Listeners
  - Amplified music
- Dance clubs
- Concerts
  - Attendees & Employees
- Classical Music
- Portable listening devices

15 year old male following right cerumen removal daily PSS use “all the way up”

14-year-old male (seen 4/09)
Did not pass school hearing screen
Max volume on iPod, 60 min/day
DPOAEs, 14-year-old iPod users (1 ½ years), *notched audiogram*

- Reduced or absent DPOAEs at frequencies 4000 Hz and above re: 95% normals (Gorga, et al., 1997)

**Predicted hearing loss**

- Normal hearing to 20 years of exposure at 100% dose

**How do we measure PLDs?**
PLD Measurement Techniques

- KEMAR (ISO 11904-2)
  - Accurate measurements
  - Requires “research” equipment

PLD Measurement Techniques

- Probe Microphone (ISO 11904-1)
  - Can use “research” probe microphone
    - Etymotic ER-7c
  - Can use “clinical” probe microphone

STOP

We can’t just use the output level measured at the eardrum!
“Free-Field Equivalent Output Level”

Output level at eardrum

- Transfer Function of the Open Ear (TFOE)

= Free-field Equivalent Output Level

• The Free-Field Equivalent Output Level can be compared to damage-risk criteria that use free-field measurements.

Why Free-Field Equivalent?

• Bare microphone underestimates by 8 dB

• Closed cavity overestimates by 5-9 dB

Keith, Michaud, Chiu (2008)
Free-field Equivalent Output Level +
Listening durations =
Noise Dose

Clinical Measurements with Verifit

1. Measure Transfer Function of Outer Ear
   - Swept tone
2. Measure Output of PLD
   - “Live Speech” (speaker off)
3. Corrections
   - Subtract TFOE, apply A-Weighting
4. Powersum to get overall level
But… I hate doing math!
There’s a handy spreadsheet for this!

Portnuff, Fligor & Arehart, In preparation

Output levels of music

Averaged across players, no sig diff (1-way ANOVA, p > .05)

Figure 1. Free-field equivalent output levels of 5 mp3 players, using stock earphones, as a function of volume control settings. Error bars represent 1 standard deviation around the grand average.

Are all PLDs the same?

<table>
<thead>
<tr>
<th>Player</th>
<th>Output level increase with 10% volume control increase</th>
<th>Voltage at 100% of volume control, 1kHz tone</th>
<th>Voltage at 10% of volume control, 1kHz tone</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPod</td>
<td>5.93 dBA</td>
<td>534 mV</td>
<td>0.9 mV</td>
</tr>
<tr>
<td>iPod Mini</td>
<td>6.10 dBA</td>
<td>577 mV</td>
<td>0.93 mV</td>
</tr>
<tr>
<td>iPod Nano</td>
<td>6.30 dBA</td>
<td>450 mV</td>
<td>0.75 mV</td>
</tr>
<tr>
<td>Creative Zen Micro</td>
<td>5.81 dBA</td>
<td>448 mV</td>
<td>1.0 mV</td>
</tr>
<tr>
<td>Sandisk Sansa</td>
<td>6.61 dBA</td>
<td>284 mV</td>
<td>0.35 mV</td>
</tr>
</tbody>
</table>
Are all earphones the same?

- Stock Earphones:
  - 101-108 dBA (Keith, Michaud, Chiu, 2008)
  - 97-104 dBA (Portnuff & Fligor, In preparation)
  - 102.5 (Keppler et al, 2010)

Significant effect of earphone sensitivity and seal in ear
- Maximum output up to:
  - 120 dBA (Keith et al, 2008)
  - 107 dBA (Portnuff & Fligor, in Preparation)

So... what criteria do we use?

- Damage-risk Criteria
  - OSHA (90 dBA, 5 dB exchange ratio)
  - NIOSH (85 dBA, 3 dB exchange ratio)
  - WHO (80 dBA, 3 dB exchange ratio)

- Percentage of noise dose?
  - 50%
  - 100%
  - Some other percentage?
Listening Behavior

- **Self-report**
  - 14% of university students listen at 80-100% (Ahmed, King, Morrish, Zazewska, and Pichora-Fuller, 2006)
  - 35% listened “loud”, 6% listened “very loud” (Torre, 2008)

- **Measured CLL**
  - 25% of listeners exceeded 85 dB $L_{\text{Aeq,8h}}$ (Williams, 2005)
  - 6% of doctoral students >85 dBA in quiet (Fligor & Ives, submitted)
  - Up to 80% >85 dBA in noise (Fligor & Ives, submitted)

How many people are at risk?

-how many people are at risk?

Portnuff, Fligor & Arehart (2009) In preparation
Self-reported Listening

- Average listening time: 2 hours
- Self-reported CLL:
  - 74.09 dBA (range: 52.32 dBA - 91.83 dBA, st dev: 10.82 dBA)

<table>
<thead>
<tr>
<th></th>
<th>OSHA</th>
<th>NIOSH/ACGIH</th>
<th>EU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Noise Dose</td>
<td>8.0%</td>
<td>20.9%</td>
<td>66.4%</td>
</tr>
<tr>
<td>Noise Dose Range</td>
<td>0-74.1%</td>
<td>0-241.0%</td>
<td>0-765%</td>
</tr>
<tr>
<td>Subjects exceeding:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% Noise Dose</td>
<td>1 (3.4%)</td>
<td>4 (13.8%)</td>
<td>7 (24.1%)</td>
</tr>
<tr>
<td>100% Noise Dose</td>
<td>0 (0%)</td>
<td>2 (6.9%)</td>
<td>4 (13.8%)</td>
</tr>
</tbody>
</table>

Listening Time Guidelines

- Time to 50% noise dose, NIOSH damage-risk criteria

<table>
<thead>
<tr>
<th>% of Volume Control</th>
<th>Minimum listening time per day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Earbuds</td>
</tr>
<tr>
<td>10-50%</td>
<td>No limit</td>
</tr>
<tr>
<td>60%</td>
<td>No limit</td>
</tr>
<tr>
<td>70%</td>
<td>6 hours</td>
</tr>
<tr>
<td>80%</td>
<td>1.5 hours</td>
</tr>
<tr>
<td>90%</td>
<td>22 minutes</td>
</tr>
<tr>
<td>100%</td>
<td>3 minutes</td>
</tr>
</tbody>
</table>

NOTE: Do NOT over-interpret this table to suggest “isolator” headphones are more “dangerous”!

Extrapolating iPod-induced HL

- >100 million .mp3 players sold since hit market 2001 (~70% of market share Apple iPod; 275 million projected sales by 2011 (Ethier, 2008)

- A Conservative Estimate for today's teenagers
  - 7% at risk for hearing loss from typical usage
  - Consider the 0.1 fractile (only the most susceptible)
  - 0.7% of 100 million: 700,000 could be expected to sustain a “material hearing impairment” if they listen for long enough time (e.g., years)
Extrapolating iPod-induced HL
• 700,000 with iPod-induced hearing loss
• 900,000 with congenital SNHL
• 10,000,000 with noise induced hearing loss

Evaluating the PLD user
• Survey measures to identify extent of PLD use
  • Audiometric Evaluation
    • Pure-tone monitoring
    • OAE monitoring
  • PLD measurements
  • PLD use counseling

Counseling the PLD User
• Consider Noise Dose
  • Dose is cumulative through the day
  • PLDs are only one part of the daily exposure
    • Occupational exposure
    • Recreational exposure
  • Consider variations in exposure level
    • Are there times when the level is significantly lower or higher?
Counseling the PLD User

- Consider listening environment
- Always higher listening in background noise
- Average preferred SNR +4 to +13 dB

- Consider earphones
  - Earphone sensitivity affects output level
  - Isolation affects SNR & chosen level

Final Messages

- MIHL is ENTIRELY preventable

- Portable listening devices are not inherently dangerous – most are used safely!

- Audiologists are the single professional with the knowledge to educate students and professionals about MIHL

Final Messages

- For a musician, MIHL is an occupational hazard/risk/disease

- Musicians may think differently than your average patient

- Those occupationally exposed to music need an audiologist like everyone needs a dentist