Differences and Intersubject Variability of Loudness Discomfort Levels Measured in Sound Pressure Level and Hearing Level for TDH-50P and ER-3A Earphones

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Abstract

Loudness discomfort levels (LDLs) were measured in dB HL and SPL at discrete frequencies between 500 to 4000 Hz on 31 hearing-impaired ears using TDH-50P and ER-3A earphones. The results revealed no significant differences in the measured sound pressure level (SPL) between the two earphones at all test frequencies. However, with dB HL measurements, statistically significant differences were revealed at 1500 and 4000 Hz between earphone conditions. The results also revealed large intersubject differences in the measured LDL (HL and SPL) for both earphones. The results of this study highlight the difficulty in accurately predicting individual performance from averaged group data.

Key Words: Intersubject variability, loudness discomfort level (LDL), real-ear aided response (REAR), real-ear insertion gain (REIG)

Abbreviations: ER = etymotic research™; GS = Grason-Stadler; IHAFF = Independent Hearing Aid Fitting Forum; LDL = loudness discomfort level; REAR = real-ear aided response; REIR = real-ear insertion response; REM = real-ear measures

Real-ear measures (REM) have become increasingly popular over the past several years. Currently, the primary use of REM is to determine if the measured real-ear insertion gain (REIG) matches a prescribed REIG. Recently, increased attention has been placed upon using REM to directly measure the sound pressure level (SPL) near the eardrum corresponding to the individual’s “auditory area” between threshold and suprathreshold levels (Kiessling, 1987; Cox and Alexander, 1990; Humes and Houghton, 1992; Zelisko et al, 1992a, b; Seewald et al, 1993; Kruger and Kruger, 1994; Valente et al, 1994a; Pluvinage et al, 1995). This “target” could serve to determine if the real-ear aided response (REAR) for frequency-specific or composite speech signals is placed within the individual’s “auditory area” using either single or multiple input levels (Hawkins, 1987; Kawell et al, 1988; Feigin et al, 1989; Hawkins et al, 1989; Cox and Alexander, 1990; Hawkins et al, 1990; Gagne’ et al, 1991a, b; MacPherson et al, 1991; Stelmachowicz and Seewald, 1991; Stuart et al, 1991; Zelisko et al, 1992a, b; Skinner et al, 1993, 1994; Valente et al, 1994a).

Recently, two manufacturers (i.e., Madsen and Qualitone) introduced equipment that measures the SPL near the eardrum while the patient completes a loudness scaling task and frequency-specific stimuli are presented via insert earphones. A third manufacturer (i.e., ReSound) is evaluating equipment (Pluvinage et al, 1995) where the SPL is measured near the eardrum as frequency-specific stimuli are presented via a loudspeaker while the patient completes loudness scaling. Finally, another manufacturer (i.e., Starkey) is in the process of testing a system that will predict the SPL at the eardrum after the patient completes a loudness scaling task. Thus, there is increased interest in using loudness scaling techniques (IHAFF, 1994).
and measuring the SPL at the eardrum as another method to select and fit hearing aids.

Clinicians often consider the effect of the earphone when measuring threshold and suprathreshold levels. Currently, at least two earphones are routinely used to measure threshold and suprathreshold levels. These include conventional (i.e., TDH series) and insert (i.e., ER-3A) earphones. Some concern has been expressed relative to differences in the measured low- (i.e., below 500 Hz) and high-frequency (i.e., above 4000 Hz) thresholds between these two earphones when the dependent variable is hearing level (dB HL) (Clemis et al, 1986; Clark and Roeser, 1988; IHAFF, 1994).

Some have suggested that only the ER-3A should be used when threshold measures are obtained for the purpose of fitting hearing aids. This argument is based upon the fact that, when placed in the ear canal, the medial end of the ER-3A is closer to the space occupied by the medial end of the shell of a hearing aid or earmold (Clemis et al, 1986; Lilly and Purdy, 1993; IHAFF, 1994) than is the conventional headset. Another argument for using the ER-3A when fitting hearing aids is that the ER-3A is calibrated to the same 2-cc coupler used by manufacturers to measure the performance of hearing aids (ANSI, 1987). Therefore, the argument for promoting the use of the ER-3A suggests that it allows for a convenient way to convert the thresholds measured in dB HL to dB SPL when measured in a 2-cc coupler by using the conversions provided in ANSI (1989). However, it can also be argued that it is equally convenient to convert thresholds measured in dB HL using a TDH series earphone, calibrated in a 6-cc coupler, to dB SPL measured in a 2-cc coupler. Hawkins et al (1990) and Bentler and Pavlovic (1989) report data for converting dB HL, measured in a 6-cc coupler, to dB SPL measured in a 2-cc coupler.

The present study measured the loudness discomfort level (LDL) in dB SPL and dB HL at six discrete frequencies between 500 to 4000 Hz using a conventional (TDH-50P) and an insert (ER-3A) earphone. The major purpose of the study was to determine if significant differences were present in the measured LDLS between the two earphones for either dependent variable (dB HL or dB SPL). In addition, the authors were also interested in determining the magnitude of the intersubject variability of the LDL when measured in either dB HL and SPL for the two earphones.

SUBJECTS AND PROCEDURES

Subjects

The experimental group included 31 ears from 17 hearing-impaired adult subjects. One ear from each of three subjects could not be evaluated due to the presence of a surgically altered ear canal or excessive cerumen. The test ear demonstrated normal middle ear function (i.e., middle ear pressure within ± 50 daPa; static compliance between 0.6-1.8 mL) using a Y226 probe tone from a calibrated middle ear analyzer (Grason-Stadler [GS1, 1733]. Air-conduction thresholds (ANSI, 1989) and LDLS were measured using a GS 16 clinical audiometer while the subject was seated in a double-walled sound suite. Figure 1 reports the mean hearing levels, collapsed across the right and left ears, for the 31 ears. Also provided is ± 1 standard deviation.

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Procedures

For each subject, LDL measurements were obtained at octave and mid-octave intervals between 500 to 4000 Hz with TDH-50P and ER-3A (50 ohm) earphones connected to the output of a calibrated GS 16 audiometer (ANSI, 1989). The LDL was measured in dB HL and SPL for the two earphones using a 6-point loudness rating scale that included “very soft,” “soft,” “comfortable,” “loud,” “very loud,” and “too loud.” The initial presentation level was 30 dB above threshold. From this point, the intensity was increased in 10-dB increments until the subject indicated that the signal was “too loud.” The intensity was then decreased in 5-dB steps until the subject indicated that the signal was “comfortable.” The intensity was then increased in 2-dB steps until the subject indicated that the signal was “very loud.” The final LDL (in dB HL or SPL) was the average of the measured LDLs between “loud” and “very loud.” Measures were obtained only once because previous studies (Clark and Roeser, 1988; Larson et al., 1988; Wilber et al., 1988; Borton et al., 1989; Valente et al., 1990, 1991; Frank and Vavrek, 1992) reported excellent test–retest reliability for the earphones and equipment used in this study.

For LDLs corresponding to the measured SPL near the eardrum, a probe tube was coupled to a probe microphone from a Frye 6500 real-ear analyzer. The probe microphone was calibrated daily using the procedures suggested by the manufacturer. The probe tube was placed along the canal wall and the tip of the probe tube was approximately 4 to 6 mm from the eardrum. This was accomplished by marking the probe tube 30 mm from the tip and placing this mark at the intratragal notch of the pinna. The probe tube was then taped to prevent movement. In the average adult ear, this should place the tip of the probe tube approximately 4 to 6 mm from the eardrum, which is necessary for accurate measures (Zemplenyi et al., 1985; Gilman and Dirks, 1986; Dirks and Kincaid, 1987).

The ER-3A was coupled to the ear canal using an appropriately sized GS immittance probe cuff. For this study, an immittance cuff was placed on a plastic adapter (ER3-06) connected to the sound outlet tube and coupled to the ER-3A and then to the ear canal. Immittance cuffs were used for several reasons. First, the diameter of the ear canal of several subjects was either too large or small to successfully use the standard foam plug. Frank and Vavrek (1992) reported that 17 percent of their subjects had ear canals that would not allow the standard foam plug to be used successfully. On the other hand, the immittance cuffs used in this study have outside diameters varying from 2 to 22 mm. In addition, the length of each immittance cuff is 16 mm. Insertion of the cuff so that the outside edge is flush with the opening of the ear canal ensured a consistent depth of 16 mm past the opening of the ear canal for all subjects. This depth is precisely the 15- to 16-mm insertion depth recommended by the manufacturer for a “deep” insertion. Borton et al. (1989) reported no significant differences in threshold when ER-3A earphones were connected to either foam plugs or immittance cuffs. Finally, when making measures with the TDH-50P, great care was taken so that the diaphragm was centered over the orifice of the ear canal.

To measure the SPL near the eardrum, the reference microphone was “disabled” and the measured SPL was read directly from the video monitor when activating the “Calibrate Probe” software of the Frye 6500. Finally, all treatment levels of the two independent variables for earphone (TDH-50P and ER-3A) and frequency (500, 1000, 1500, 2000, 3000, and 4000 Hz) were counterbalanced to control for order effects. Separate two-factor (earphone × frequency) ANOVAs were performed on the two dependent variables (dB HL and dB SPL) to determine if significant differences were present in the measured LDL between the two earphone conditions across the six test frequencies.

RESULTS

Mean Difference between Earphones

SPL

Table 1 reports the mean, standard deviation, minimum-maximum LDL, magnitude of the range, and the standard error of the mean difference of the LDL measured in SPL for the two earphones. Also, provided is the Pearson product–moment correlation coefficient (r) of the measured LDL between the two earphones at each frequency. The mean difference in the measured SPL between the two earphones ranged from −0.9 dB at 1500 Hz to +0.4 dB at 500 Hz. A two-factor repeated measures ANOVA (earphone × frequency) revealed no significant
Table 1  Mean, Standard Deviation, Minimum-Maximum, and Range of Measured Real-Ear LDL (dB SPL) for the TDH-50P and ER-3A Earphones at Six Test Frequencies*

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>500</th>
<th>1000</th>
<th>1500</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
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</thead>
<tbody>
<tr>
<td>TDH-50P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>108.8</td>
<td>104.5</td>
<td>106.0</td>
<td>108.8</td>
<td>108.7</td>
<td>106.3</td>
</tr>
<tr>
<td>SD</td>
<td>9.3</td>
<td>8.4</td>
<td>9.0</td>
<td>9.6</td>
<td>11.4</td>
<td>13.4</td>
</tr>
<tr>
<td>Minimum-maximum</td>
<td>90-127</td>
<td>85-120</td>
<td>83-122</td>
<td>85-127</td>
<td>85-135</td>
<td>84-132</td>
</tr>
<tr>
<td>Range (dB)</td>
<td>37</td>
<td>35</td>
<td>39</td>
<td>42</td>
<td>51</td>
<td>48</td>
</tr>
<tr>
<td>ER-3A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>108.4</td>
<td>104.9</td>
<td>106.9</td>
<td>109.5</td>
<td>109.1</td>
<td>106.5</td>
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<tr>
<td>SD</td>
<td>9.3</td>
<td>7.9</td>
<td>8.9</td>
<td>9.9</td>
<td>11.3</td>
<td>13.1</td>
</tr>
<tr>
<td>Minimum-maximum</td>
<td>87-124</td>
<td>89-119</td>
<td>87-122</td>
<td>85-126</td>
<td>84-129</td>
<td>84-129</td>
</tr>
<tr>
<td>Range (dB)</td>
<td>37</td>
<td>30</td>
<td>35</td>
<td>41</td>
<td>45</td>
<td>46</td>
</tr>
<tr>
<td>Mean difference</td>
<td>+0.4-0.4</td>
<td>-0.9-0.7</td>
<td>-0.7-0.4</td>
<td>-0.4-0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard error of the mean difference</td>
<td>0.54-0.47</td>
<td>0.41-0.46</td>
<td>0.46-0.46</td>
<td>0.69-0.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>0.93</td>
<td>0.92</td>
<td>0.93</td>
<td>0.94</td>
<td>0.96</td>
<td>0.90</td>
</tr>
</tbody>
</table>

+ = mean dB SPL for TDH-50P greater than mean dB SPL for ER-3A; − = mean dB SPL for TDH-50P less than mean dB SPL for ER-3A.

Also provided is the mean difference, the standard error of the mean difference, and the Pearson product-moment correlation (r) of the measured LDL, in dB SPL, at each frequency between the two earphones.

*N = 31 ears.

Within the limits of regression analysis (i.e., numerous data points do not "fit" on the "line of best fit" and are somewhat limited to the equipment and procedures used in this study),

Figures 2 and 3 reveal scatterplots, Y intercept (a), regression coefficient (b), and the line of best fit at 500 to 4000 Hz for the TDH-50P (Fig. 2) and ER-3A (Fig. 3) earphones for the LDL measured in dB SPL. For each scatterplot, hearing level (dB HL) appears along the abscissa and the LDL (dB SPL) appears along the ordinate. The triangles represent the individually measured LDL. At some frequencies, less than 31 data points are present because LDL measures for several ears were at the same SPL for the same level of hearing loss.

Figure 2  Scatterplots at 500–4000 Hz (A–F) for LDLs measured in dB SPL as a function of hearing level with the TDH-50P earphone. Also provided is the value of the Y intercept (a), regression coefficient (b), and the line of best fit.
Loudness Discomfort Levels / Valente et al

500 Hz

\[ a = 107.52 \]
\[ b = 0.43 \]

1000 Hz

140
120
100
80
60
40
20

\[ a = 111.47 \]
\[ b = 0.03 \]

2000 Hz

Where \( Y' \) is the predicted LDL measured in dB SPL, \( a \) is the \( Y' \) intercept, \( b \) is the regression coefficient, and \( X \) is hearing level measured in dB HL. For example, in Figure 2A, using the data reported for the 31 ears in this study, the predicted LDL (dB SPL) at 500 Hz for a threshold of 30 dB HL would be 108.71 + 0.03 (30) or 109.6 dB SPL (Kerlinger, 1973). Notice in Figures 2 and 3 that the line of best fit at 500 to 2000 Hz is virtually flat, indicating that LDL remains essentially constant as hearing level increases from 0 to 100 dB HL. Also notice that the line of best fit increases gradually at 3000 and 4000 Hz, indicating that the LDL increases as hearing level increases. This finding is in general agreement with the findings reported by Kamm et al (1978), Dillon et al (1984), Hawkins et al (1987), and Pascoe (1988).

Hearing Level

Table 2 reports the mean, standard deviation, minimum-maximum LDL, magnitude of the range, and the standard error of the mean difference of the LDL measured in dB HL for the two earphones. Also provided is the Pearson product-moment correlation \( r \) of the measured LDL between the two earphones at each frequency. The Pearson product-moment correlations ranged from 0.91 at 4000 Hz to 0.97 at 3000 Hz. The very high correlations indicate that an LDL measured using one earphone would result in a very similar LDL using the other earphone.

Table 2 Mean, Standard Deviation, Minimum-Maximum, and Range of Measured LDL (dB HL) for the TDH-50P and ER-3A Earphones at Six Test Frequencies*

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>500</th>
<th>1000</th>
<th>1500</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDH-50P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>96.8</td>
<td>95.7</td>
<td>96.7</td>
<td>93.3</td>
<td>95.1</td>
<td>98.9</td>
</tr>
<tr>
<td>SD</td>
<td>8.9</td>
<td>8.1</td>
<td>9.0</td>
<td>9.1</td>
<td>11.5</td>
<td>13.6</td>
</tr>
<tr>
<td>Minimum-maximum</td>
<td>80–118</td>
<td>78–122</td>
<td>76–112</td>
<td>74–120</td>
<td>74–120</td>
<td>74–120</td>
</tr>
<tr>
<td>Range (dB)</td>
<td>38</td>
<td>44</td>
<td>36</td>
<td>46</td>
<td>50</td>
<td>46</td>
</tr>
<tr>
<td>ER-3A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>96.6</td>
<td>94.8</td>
<td>94.6</td>
<td>92.7</td>
<td>93.6</td>
<td>95.8</td>
</tr>
<tr>
<td>SD</td>
<td>8.9</td>
<td>8.0</td>
<td>9.0</td>
<td>9.2</td>
<td>11.4</td>
<td>12.7</td>
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<tr>
<td>Range (dB)</td>
<td>34</td>
<td>30</td>
<td>36</td>
<td>36</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Mean difference</td>
<td>+0.2</td>
<td>+0.9</td>
<td>+2.1</td>
<td>+0.6</td>
<td>+1.5</td>
<td>+3.1</td>
</tr>
<tr>
<td>Standard error of the mean difference</td>
<td>0.66</td>
<td>0.51</td>
<td>0.48</td>
<td>0.59</td>
<td>0.71</td>
<td>0.73</td>
</tr>
<tr>
<td>( r )</td>
<td>0.93</td>
<td>0.93</td>
<td>0.94</td>
<td>0.96</td>
<td>0.97</td>
<td>0.91</td>
</tr>
</tbody>
</table>

\* = mean dB HL for THD-50P greater than mean dB HL for ER-3A.

Also provided is the mean difference, the standard error of the mean difference, and the Pearson product-moment correlation \( r \) of the measured LDL, in dB HL, at each frequency between the two earphones.

*\( N = 31 \) ears.
The mean difference in the measured LDL in dB HL between the two earphones ranged from +0.2 dB at 500 Hz to +3.1 dB at 4000 Hz. A two-factor repeated measures ANOVA (earphone × frequency) revealed a significant two-factor interaction ($F = 4.90; df = 5/245; p < .01$), indicating that significant differences were revealed between earphones. This finding indicated that the mean differences in measured HL between the earphone conditions were not constant across test frequencies. A one-factor repeated measure ANOVA was performed at each test frequency to determine if the mean differences in measured HL between each earphone were significantly different. The results revealed that the mean LDL in HL produced by the TDH-50 was significantly greater than the LDL in HL measured by the ER-3A at 1500 Hz ($F = 19.2; df = 1/49; p < .01$) and 4000 Hz ($F = 24.83; df = 1/49; p < .01$). Although the differences at these two frequencies were found to be statistically significant, the mean differences of 2.1 and 3.1 dB at 1500 and 4000 Hz, respectively, would probably not be judged as clinically significant.

Finally, as was also found when LDL was measured in dB SPL, the range of measured LDLs at any frequency was as small as 30 dB at 1000 Hz for the ER-3A to as great as 50 dB at 3000 Hz for the TDH-50P. As a general rule, the range of the measured LDL across ears increased as frequency increased for both earphones.

Figures 4 and 5 reveal the scatterplots, Y intercept (a), regression coefficient (b), and line of best fit at 500 to 4000 Hz for the TDH-50P (Fig. 4) and ER-3A (Fig. 5) with the LDL measured in dB HL. For each scatterplot, the hearing level (dB HL) appears along the abscissa and the LDL (dB HL) appears along the ordinate. The triangles represent the individual LDL measured in dB HL. As described earlier, these figures can be used to predict the LDL in dB HL from the hearing level measured using either the TDH-50P or ER-3A insert earphone. Notice in Figures 4 and 5 that the line of best fit is virtually flat at 500 to 1500 Hz, indicating that LDL remains essentially constant as hearing level increases from 0 to 100 dB HL. Also notice that the line of best fit increases gradually at 2000, 3000, and 4000 Hz, indicating that LDL increases as hearing level increases. Again, this finding is in general agreement with the findings reported by Kamm et al (1978), Dillon et al (1984), Hawkins et al (1987), and Pascoe (1988).

**Figure 4** Scatterplots at 500–4000 Hz (A–F) for LDLs measured in dB HL as a function of hearing level with the TDH-50P earphone. Also provided is the value of the Y intercept (a), regression coefficient (b), and the line of best fit.

**Figure 5** Scatterplots at 500–4000 Hz (A–F) for LDLs measured in dB HL as a function of hearing level with the ER-3A earphone. Also provided is the value of the Y intercept (a), regression coefficient (b), and the line of best fit.
**Intersubject Variability**

The ranges reported in Tables 1 and 2 and the triangles in Figures 2 to 5 illustrate the large degree of intersubject variability found in the 31 ears used in this study. Tables 1 and 2 revealed that, at any test frequency, summed across hearing levels, the magnitude of the intersubject variability was as small as 30 dB to as great as 51 dB, depending upon frequency and earphone. Figures 2 to 5 report individual LDLs for the two earphones at the six test frequencies as a function of hearing level. For example, in Figure 2D, the range of LDL measured in dB SPL for the TDH-50P earphone at 1500 Hz with a hearing level of 60 dB was between 85 to 130 dB. Similar wide ranges in intersubject variability (i.e., the ordinate) can be seen at the other test frequencies for either earphone at other hearing levels (i.e., the abscissa) for measures in either dB HL or dB SPL. Similar findings of the wide range in intersubject variability in LDL have been reported by Kamm et al (1978), Dillon et al (1984), Hawkins et al (1987), Pascoe (1988), and Sammeth et al (1993). All of these investigators have cautioned about the difficulty of predicting LDL from threshold measures. The results of the present study serve to reinforce the findings of the past.

**DISCUSSION**

The lack of significant differences in measured SPL between the two earphones at any test frequency should be of interest to clinicians pursuing in situ measures of the “auditory area” when fitting hearing aids. From the findings in this study, it appears that clinicians can use either earphone and the resulting measure of dB SPL near the eardrum should be approximately equal. Of course, the clinician will want to be sure that the probe microphone is calibrated to the manufacturer’s specifications. That is, the accuracy of the LDL measures in dB SPL appears to be more closely related to the calibration of the probe microphone as well as all of the other well-documented issues involved with the accurate measures of threshold (i.e., stimuli, instructions, procedures, etc.) than the type of earphone. The lack of differences in the measured LDL (in dB SPL) between earphones is related to the fact that the SPL required to elicit a psychoacoustic sensation of “loud” or “very loud” should be the same regardless of the transducer.

These results are in contrast to the results reported by Valente et al (1994b), who reported significant differences in the measured SPL between TDH-39P and ER-3A earphones. However, in the Valente et al (1994b) study, the attenuator was fixed at 90 dB HL and the primary focus was to determine the range of intersubject differences in measured SPL between the two earphones.

The mean difference in LDLs between the two earphones measured in dB HL (see Table 2) is consistent with the results reported in several studies in which audiometric threshold was the dependent variable. For example, Clemis et al (1986) reported mean differences from 1.21 dB (1000 Hz) to 2.59 dB (4000 Hz), Larson et al (1988) reported mean differences of 0.3 dB (2000 Hz) to 7.0 dB (4000 Hz), Clark and Roesser (1988) reported mean differences no greater than 2.8 dB at 500 to 4000 Hz. Lindgren (1990) reported mean differences of 1.3 dB (2000 Hz) to 2.9 dB at 500 Hz. Finally, Frank and Vavrek (1992) reported mean differences of 4.0 dB (1000 Hz) to 6.6 dB (2000 Hz). Thus, it appears as if the mean differences reported for threshold measures are consistent with the mean differences reported for LDL measures. The fact that the differences between the earphones are similar across so many studies is quite remarkable in view of the fact of the presence of the differences across procedures across the numerous studies. These differences include type of earphone (TDH-39, TDH-49, and TDH-50), method of coupling the ER-3A to the ear canal (immittance probe tip and foam plug), and the depth of insertion of the ER-3A in the ear canal (shallow vs deep). In fact, Wilber et al (1988) reported that thresholds for the ER-3A could change from 0.6 dB to 2.2 dB at 500 to 4000 Hz if the depth of insertion of the ER-3A into the ear canal was shallow (10 mm) versus deep (16 mm). Thus, although the mean differences between the LDLs for the TDH-50P and ER-3A were found to be statistically significant at 1500 and 4000 Hz (2.1 and 3.1 dB, respectively), it appears as if this magnitude of difference is in general agreement with the results reported in the past and would not appear to be clinically significant by most clinicians.

Finally, the scatterplots of Figures 2 to 5 and the ranges reported in Tables 1 to 2 should convince most clinicians of the potential error of predicting individual LDL from threshold measures. As mentioned earlier, hardware and software is currently available to measure automatically the individual’s LDL in dB HL, dB SPL in a 2-cc coupler, or dB SPL measured near the eardrum. For example, the IHAFF software
allows clinicians to measure frequency-specific LDLs automatically via communication with selected audiometers. Equipment available from ReSound (P3), Qualitone (Prophet), Madsen (Auricle), and Starkey allow for loudness scaling via either a dedicated programmer (P3) or personal computer (Qualitone, Madsen, and Starkey). Further, the Qualitone and Madsen units contain hardware that allows for direct measure of the SPL near the eardrum. In addition, software in the Starkey system predicts the SPL measured near the eardrum as loudness scaling is completed.

The available technology does not appear to provide clinicians with any justifiable reason to simply complete an audiogram and allow software to predict the LDL using algorithms based upon average group data (Killion, 1994). Equipment is available that allows clinicians to measure individual loudness scaling in a clinically efficient manner. Furthermore, technology is available for clinicians to measure the SPL near the eardrum when performing loudness scaling procedures. What remains to be demonstrated is whether these methods (loudness scaling and measuring thresholds in dB SPL near the eardrum) result in methods for selecting and fitting hearing aids that are equal to or better than the current popular method of prescriptive fittings using functional or real-ear insertion gain.

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REFERENCES


