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Tympanometric Measures in Older Adults

Terry L. Wiley*
Karen J. Cruickshanks†
David M. Nondahl†
Ted S. Tweed*
Ronald Klein†
Barbara E. K. Klein†

Abstract

Tympanometric measures were obtained in 1240 adults (2147 ears) ranging in age from 48 to 90 years. All subjects reported a negative history of otic disease, passed an otoscopic examination, and did not present a significant air-bone gap based on pure-tone audiometry. Relative to findings for younger adults, tympanometric measures for older adults in the present study showed greater variability, a slightly lower mean peak compensated static acoustic admittance (peak Y_{tm}), and a significantly higher mean equivalent ear-canal volume (V_{ea}). Across age in the present study, V_{ea} tended to decrease with age and tympanogram width (TW) tended to increase with age. Relative to measures for females, males in the present study tended to have higher peak Y_{tm} values, higher V_{ea} values, and slightly lower TW values. Overall, our findings indicate a need to adopt criteria that account for age and gender effects in tympanometry protocols for older adults.

Key Words: Admittance, aging, immittance, middle ear, presbycusis, screening, tympanometry

Investigations over the past 20 years have produced conflicting results regarding changes in middle-ear function with advancing age. Several investigators have reported decreased acoustic admittance at the eardrum with age (Alberti and Kristensen, 1972; Jerger et al, 1972; Blood and Greenberg, 1977; Hall, 1979). Others have reported no significant change in acoustic admittance at the tympanic membrane as a function of age (Nerbonne et al, 1978; Osterhammel and Osterhammel, 1979; Thompson et al, 1979; Wilson, 1981). Finally, Beattie and Leamy (1975) reported that the acoustic admittance at the tympanic membrane was higher for 60–78 year olds than for young adults.

If acoustic-immittance measures for young and older adults differ significantly, measurement norms for young adults may be inappropriate as screening criteria for older adults. The normative data for adults provided in the middle-ear screening guidelines recommended by ASHA (1990), for example, were taken from a subject pool comprised primarily (90%) of subjects 50 years of age or younger (Margolis and Heller, 1987). There are no corresponding tympanometric data and screening criteria for older (over 50 years of age) adults. Accordingly, the primary purpose of this study was to provide normative data for the ASHA (1990) admittance screening measures in older adults. The need for such tympanometric data and middle-ear screening criteria in older adults is underscored by evidence suggesting that the prevalence of mixed hearing loss and associated middle-ear disorders may be as high as 24 percent across older male and female subjects (Moscicki et al, 1985).

METHOD

Subjects

Data were taken from the ongoing population-based study of hearing loss in older adults, the Epidemiology of Hearing Loss Study (EHLS). A private census was conducted in 1987–1988 to

*Department of Communicative Disorders, University of Wisconsin-Madison, Madison, Wisconsin; †Department of Ophthalmology and Visual Sciences, University of Wisconsin-Madison, Madison, Wisconsin

Reprint requests: Terry L. Wiley, Department of Communicative Disorders, University of Wisconsin-Madison, 1975 Willow Drive, Madison, WI 53706

identify all residents of the city or township of Beaver Dam, Wisconsin who were 43–84 years of age (n = 5924) (Campbell and Palit, 1988). Of those identified, 83 percent (n = 4926) participated in the Beaver Dam Eye Study (1988–1990), a study of age-related ocular disorders (Klein et al, 1992). Participants who were alive as of March 1, 1993 (n = 4541) were eligible for the EHLS. During the first year of the EHLS (March 9, 1993–May 31, 1994), 2309 people completed the 75-minute examination, of whom 1240 (2147 ears) met the selection criteria for the analyses in the present report.

Subjects were assigned to one of four groups according to age in years (48–59, 60–69, 70–79, 80–90). Approximately 99 percent of the subjects were non-Hispanic white. All subjects presented a negative history of otologic problems. For all test ears, there were no otoscopic signs of otic pathology and no significant (≥15 dB) air-bone gap based on pure-tone audiometry.

Procedures

Behavioral air-conduction and bone-conduction thresholds for tones were obtained at applicable octave audiometric frequencies 250 through 8000 Hz using a diagnostic audiometer (Virtual, 320). Acoustic-admittance measures were taken in one test session on the same day as the hearing tests. Measures of (1) peak compensated static acoustic admittance (peak Y_{tm}), (2) equivalent ear-canal volume (V_{ea}), and (3) tympanogram width (TW) were obtained under the same conditions used by Margolis and Heller (1987; ASHA, 1990).

Acoustic-admittance tympanograms for a probe frequency of 226 Hz were obtained with a screening tympanometer (Grason-Stadler, Model GSI 37) using a positive-to-negative direction of pressure change and a measured pump speed of 600/200 daPa/sec. The acoustic-admittance value at 200 daPa was used as the ear-canal referent for compensated admittance calculations. Otoscopy was performed in each test ear prior to the beginning of each test session. Otoscopic judgments of the external auditory meatus and tympanic membrane were recorded for the following: drainage, ear canal debris, ear canal collapse, position of the tympanic membrane, general appearance of the tympanic membrane (e.g., dull vs normal), color of the tympanic membrane, vascularity of the tympanic membrane, signs of liquid present in the middle ear, and perforations of the tympanic membrane. Demonstrated interexaminer reliability was high across otoscopic categories; examiner agreement for the otoscopic signs ranged from 73 to 100 percent (Nondahl et al, 1996). Ears with any visible otoscopic sign (e.g., scarring of the tympanic membrane) of present or past pathology were excluded from the data

Table 1 Peak Y_{tm}, V_{ea}, and TW Data for Margolis and Heller (1987) (ASHA, 1990) and for the Present (EHLS) Study

		Peak Y_{tm} (mmhos)		*V_{ea} (cm³)*		*TW (daPa)*	
	n	*Mean*	*90% Range*	*Mean*	*90% Range*	*Mean*	*90% Range*
ASHA (19–61 yr)*	87	0.72	0.3–1.4	1.05	0.8–1.6	77	48–110
EHLS (48–90 yr)							
Both Ears and Both Genders	2147	0.66	0.2–1.5	1.36	0.9–2.0	75	35–125
48–59 yr	788	0.67	0.2–1.5	1.40	0.9–2.1	69	35–110
60–69 yr	636	0.67	0.2–1.5	1.34	0.9–1.9	75	35–120
70–79 yr	550	0.65	0.2–1.5	1.35	0.9–2.0	80	35–125
80–90 yr	173	0.57	0.2–1.3	1.29	0.8–1.9	90	40–145
Male	825	0.72	0.2–1.6	1.49	1.0–2.2	73	35–125
48–59 yr	332	0.75	0.2–1.7	1.54	1.1–2.3	66	35–110
60–69 yr	258	0.67	0.2–1.4	1.46	1.0–2.1	78	35–130
70–79 yr	183	0.75	0.2–1.9	1.47	0.9–2.2	76	30–125
80–90 yr	52	0.65	0.2–1.7	1.44	1.0–1.9	87	25–140
Female	1322	0.62	0.2–1.4	1.28	0.9–1.9	76	40–120
48–59 yr	456	0.62	0.2–1.3	1.29	0.8–1.9	71	35–110
60–69 yr	378	0.66	0.2–1.5	1.26	0.9–1.8	73	35–120
70–79 yr	367	0.60	0.2–1.3	1.30	0.9–1.9	82	40–125
80–90 yr	121	0.53	0.2–1.3	1.23	0.8–1.7	91	45–145

*There were slight differences between the raw Margolis and Heller (1987) data and the published ASHA (1990) norms.

analysis. The audiometer and the tympanometer were calibrated in accordance with appropriate ANSI standards (ANSI, 1989 and ANSI, 1987, respectively).

RESULTS

Table 1 includes summary data and statistics across age group and gender for both ears combined. The adult data of Margolis and Heller (1987) reported in the ASHA guidelines (1990) also are included for comparison purposes. It should be noted that, although the subject age in the Margolis and Heller work ranged from 19 to 61 years, their mean subject age was 31.7 years. So, the majority of the Margolis and Heller subjects were young adults relative to the older adults in the present study.

Data for each measure for each ear are given in Table 2. With one exception (V_{ea}), which is discussed later, there were no significant ear differences overall or by age group or gender. Except for the case for which ear differences are discussed, the statistical analyses presented throughout are based on data for both ears combined.

Three primary statistical analyses are reported. First, data from the present study were examined for overall age effects using a Mantel-Haenszel test (Mantel and Haenszel, 1959, pp. 719–748) and for gender differences using t-tests. Second, distributions for each of the three measures in older adults from the present study were compared with distributions of the same measures in younger adults from Margolis and Heller (1987) using the Kolmogorov-Smirnov Two-Sample Test (Siegel and Castellan, 1988, pp. 144–151). Third, means for each of the three primary measures in the present study were compared to those from Margolis and Heller (1987) using t-tests.

Age Effects

Peak Y_{tm}. Peak Y_{tm} data across age groups are displayed in Table 1. Means and 90 percent ranges for both ears combined are given for each

Table 2 Peak Y_{tm}, V_{ea}, and TW Data for Older Adults in the Present (EHLS) Study

		Peak Y_{tm} (mmhos)		V_{ea} (cm^3)		TW (daPa)	
	n	*Mean*	*90% Range*	*Mean*	*90% Range*	*Mean*	*90% Range*
Right Ear							
Both Genders	1063	0.66	0.2–1.5	1.37	0.9–2.0	75	35–125
48–59	397	0.66	0.2–1.4	1.41	0.9–2.1	70	35–110
60–69	314	0.68	0.2–1.5	1.34	0.9–1.9	73	35–125
70–79	270	0.66	0.2–1.6	1.36	0.9–2.1	80	35–125
80–90	82	0.54	0.2–1.3	1.28	0.8–1.8	89	40–130
Male	407	0.72	0.2–1.7	1.50	1.0–2.3	73	35–125
48–59	168	0.77	0.3–1.7	1.55	1.1–2.3	66	35–110
60–69	124	0.67	0.2–1.3	1.45	1.1–2.1	78	40–135
70–79	93	0.76	0.2–1.9	1.46	0.9–2.3	77	25–125
80–90	22	0.56	0.2–0.9	1.46	1.0–1.9	88	40–120
Female	656	0.62	0.2–1.3	1.28	0.9–1.9	76	40–120
48–59	229	0.58	0.2–1.2	1.30	0.8–2.0	73	40–110
60–69	190	0.69	0.2–1.5	1.26	0.9–1.8	71	35–115
70–79	177	0.61	0.2–1.4	1.31	0.9–1.9	81	35–130
80–90	60	0.53	0.2–1.3	1.21	0.8–1.8	90	40–135
Left Ear							
Both Genders	1084	0.66	0.2–1.5	1.36	0.9–2.0	75	35–125
48–59	391	0.69	0.2–1.5	1.39	0.9–2.1	68	35–110
60–69	322	0.65	0.2–1.4	1.34	0.9–2.0	76	35–120
70–79	280	0.64	0.2–1.5	1.34	0.9–2.0	81	35–125
80–90	91	0.60	0.1–1.5	1.30	0.9–1.9	91	40–145
Male	418	0.72	0.2–1.6	1.49	1.0–2.2	73	35–125
48–59	164	0.73	0.2–1.4	1.53	1.1–2.1	66	35–110
60–69	134	0.68	0.2–1.5	1.46	1.0–2.2	77	35–125
70–79	90	0.75	0.2–1.7	1.47	0.9–2.2	76	30–125
80–90	30	0.72	0.3–1.7	1.43	1.0–1.9	87	25–140
Female	666	0.62	0.2–1.4	1.27	0.9–1.9	77	35–120
48–59	227	0.66	0.2–1.5	1.28	0.9–1.9	69	35–105
60–69	188	0.63	0.2–1.4	1.26	0.8–1.8	75	40–120
70–79	190	0.59	0.2–1.3	1.29	0.9–1.9	83	45–125
80–90	61	0.54	0.1–1.3	1.24	0.9–1.7	93	45–145

age group. A Mantel-Haenszel test of trend was statistically significant ($X^2[1] = 4.66$; $p = .031$). Specifically, peak Y_{tm} tended to decrease with advancing age. However, after adjusting for gender, the age trend was no longer significant ($X^2[1] = 3.14$; $p = .08$).

Equivalent Ear-Canal Volume (V_{ea}). Mean equivalent ear-canal volume as a function of age also is given in Table 1. Again, means and 90 percent ranges were combined across the two ears. A Mantel-Haenszel test (Mantel and Haenszel, 1959, pp. 719–748) for trend indicated a significant group difference ($X^2[1] = 12.85$; $p < .001$). Equivalent ear-canal volume tended to decrease as a function of age. This trend remained significant after adjusting for gender ($p = .01$). However, it should be noted that when adjusted for gender differences, the effect was significant for right ear data ($X^2[1] = 4.45$; $p = .035$) but did not reach significance for left ear data ($X^2[1] = 2.26$; $p = .13$). (Independent V_{ea} means for each gender, each ear, and each age group are given in Table 2.) This difference in statistical outcomes for data combined across ears and those for separate ears may be influenced by a number of factors including the doubling of sample size for combined data and the correlation of data for the two ears.

Tympanogram Width. Means and 90 percent ranges for TW across age groups are shown in the last two columns of Table 1; again, data shown are for both ears combined. A Mantel-Haenszel test (Mantel and Haenszel, 1959, pp. 719–748) for overall age group trend indicated a significant difference as a function of age ($X^2[1] = 106.94$; $p < .001$). TW tended to increase as a function of age. This trend remained significant after adjusting for gender ($p > .001$).

Gender Effects

Peak Y_{tm}. Independent peak Y_{tm} measures for males and females are included in Table 1; means and 90 percent ranges are shown for both ears combined. A t-test ($T[1571.7] = -4.65$; $p < .001$) indicated a significant gender difference. Mean peak Y_{tm} was significantly higher for males (0.72 mmho) relative to the mean value for females (0.62 mmho). This gender difference remained significant ($p < .001$) when adjusted for age group.

Equivalent Ear-Canal Volume (V_{ea}). Like Y_{tm}, V_{ea} means differed significantly ($T[1556] = -13.51$; $p < .001$) for females and males. Specifically, V_{ea} was smaller in female (1.28 cm^3) than in male subjects (1.49 cm^3). This gender difference also was significant ($p < .001$) when adjusted for age group.

Tympanogram Width. TW means were significantly different ($T[2145] = 2.36$; $p = .018$) for female and male subjects. Mean TW was slightly higher (less than 3 daPa) for females compared with the mean TW value in males. When adjusted for age group, however, this gender difference no longer reached significance ($p = .13$).

Comparisons with ASHA Norms

Distributions of peak Y_{tm}, V_{ea}, and TW values across all four age groups in the present study are shown in Figures 1, 2, and 3, respectively. In each figure, the distributions of adult values from Margolis and Heller (1987) also are shown for comparison. The data labelled EHLS are from the present study and the ASHA label refers to the Margolis and Heller (1987) data for adults. A Kolmogorov-Smirnov Two-Sample Test was used to compare EHLS and ASHA distributions for the three primary measures. This test indicated a significant difference in distributions for

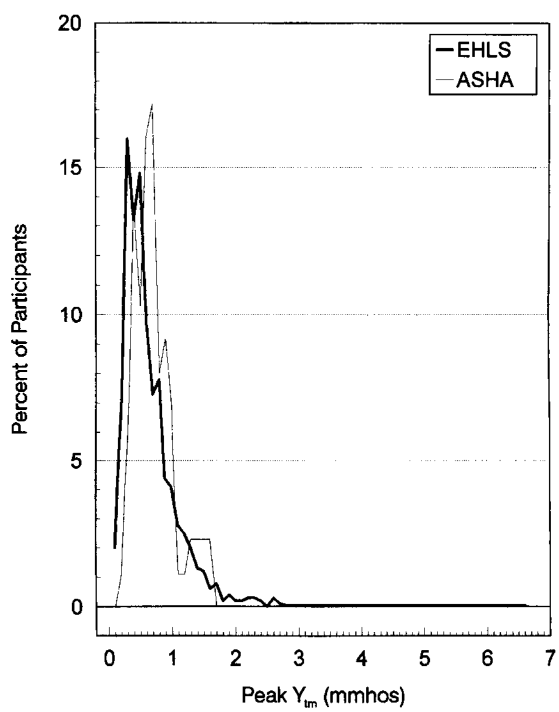

Figure 1 Distribution of Y_{tm} values from Margolis and Heller (1987) (ASHA, 1990) and the current (EHLS) study. Data for the EHLS distribution were combined across age group, gender, and ears.

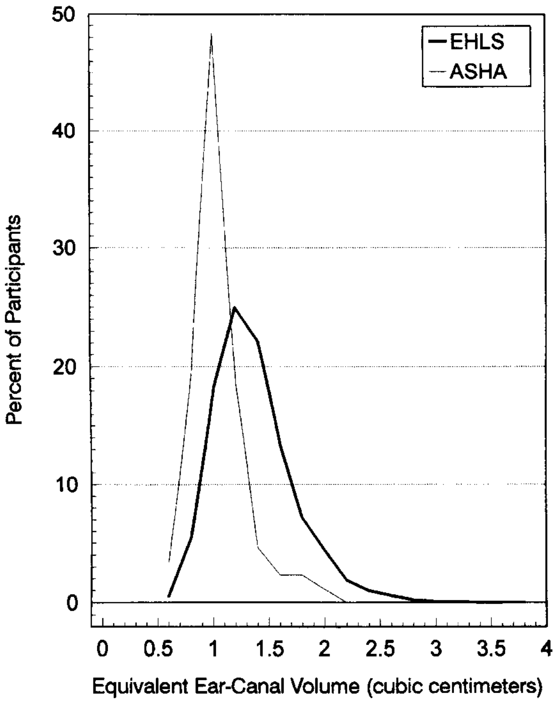

Figure 2 Distribution of V_{ea} values from Margolis and Heller (1987) (ASHA, 1990) and the current (EHLS) study. Data for the EHLS distribution were combined across age group, gender, and ears.

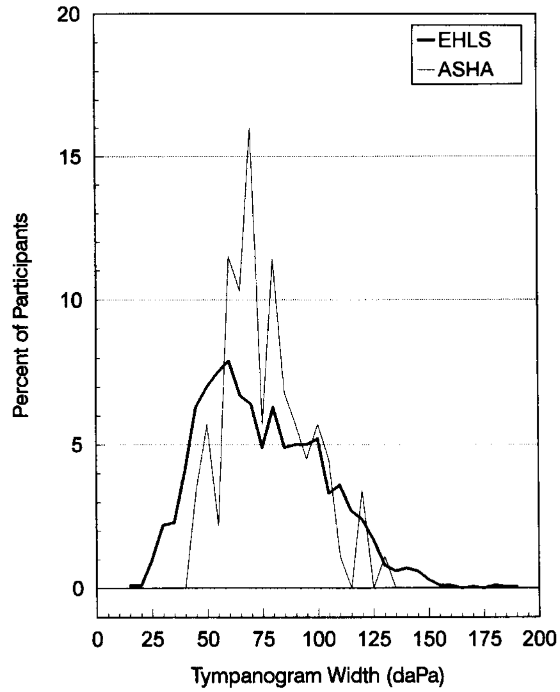

Figure 3 Distribution of TW values from Margolis and Heller (1987) (ASHA, 1990) and the current (EHLS) study. Data for the EHLS distribution were combined across age group, gender, and ears.

peak Y_{tm} ($D_{2147,87}$ = 0.2174; p < .001), V_{ea} ($D_{2147,87}$ = 0.5277; p < .001), and TW ($D_{2147,87}$ = 0.1911; p < .005). Compared with the younger adults of Margolis and Heller (1987), older adults in the present study demonstrated slightly lower peak Y_{tm} values, larger equivalent ear-canal volumes, and a slightly lower TW. The positive skew observed for Y_{tm} values (Fig. 1) in both younger and older adults is consistent with earlier findings (Wiley et al, 1987).

In addition to an analysis of distributions, means for the three primary measures were compared across ASHA and EHLS data sets. In the case of peak Y_{tm}, the mean for the ASHA sample (0.72 mmho) was not significantly different (t [102.9] = 1.77; p = .08) from that for the present (EHLS) study (0.66 mmho). There also was no significant difference in ASHA (76.8 daPa) and EHLS (75.2 daPa) means for TW (t [101.7] = −0.79; p = .43). However, there was a significant difference in V_{ea} means for the two studies. The V_{ea} mean (1.36 cm^3) for the present study was significantly higher (t [101.2] = 11.38; p < .001) than that for the ASHA adult group (1.05 cm^3).

Figures 4, 5, and 6 include means and 90 percent ranges from the present study and from Margolis and Heller (1987) for measures of peak Y_{tm}, V_{ea}, and TW, respectively. These figures illustrate the effects noted above for each measure, but more clearly demonstrate the larger variability in all measures for the older adults in the present study relative to measures for younger adults. The 90 percent ranges for older adults in the present study were clearly larger for all measures than corresponding ranges for the younger adults of Margolis and Heller (1987).

Tympanogram Peak Pressure

Although it was not a primary focus of the present study, tympanogram peak pressure (TPP) was recorded for each tympanogram. The TPP value is the ear-canal pressure (in daPa) corresponding to the peak of the acoustic admittance tympanogram. Although this measure is not recommended as a middle-ear screening measure (ASHA, 1990), it is still used for diagnostic purposes by clinical audiologists. Accordingly, it was felt that readers would be interested in TPP measures for older adults and in any observed differences in TPP for younger and older adults. Our TPP data are summarized in Table 3. Also included for comparison purposes are adult TPP data from Margolis and Heller

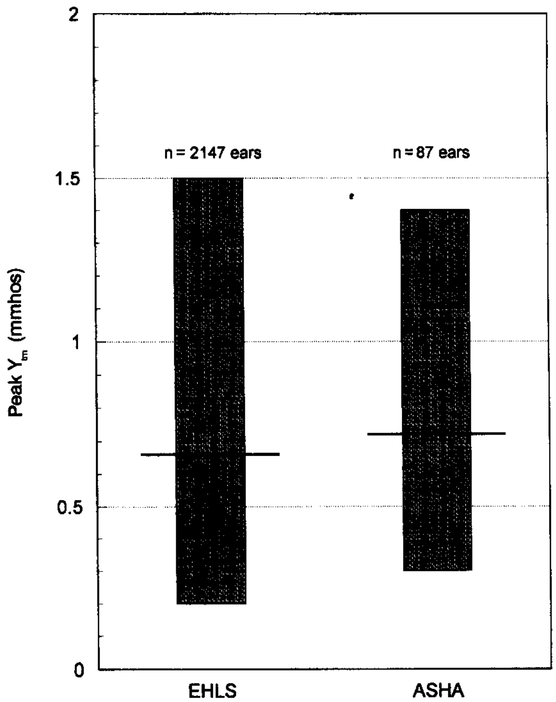

Figure 4 Mean peak Y_{tm} values (lines) and 90 percent ranges (bars) for Margolis and Heller (1987) (ASHA, 1990) and the present (EHLS) study. EHLS data were combined across age group, gender, and ears.

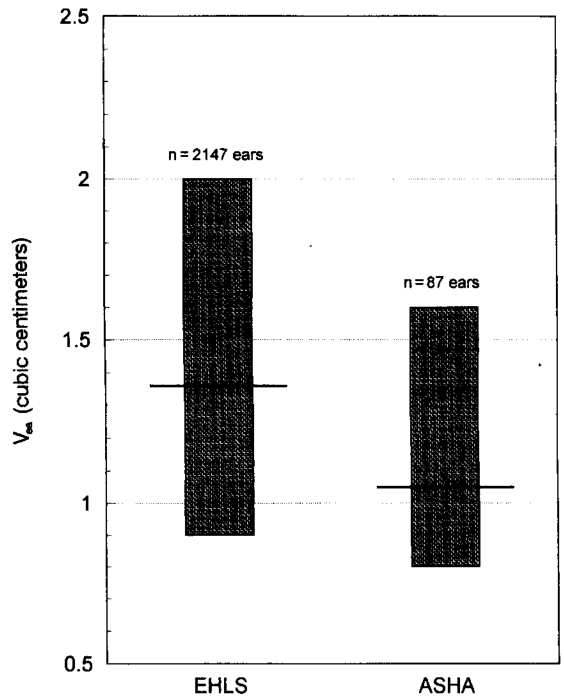

Figure 5 Mean V_{ea} values (lines) and 90 percent ranges (bars) for Margolis and Heller (1987) (ASHA, 1990) and the present (EHLS) study. EHLS data were combined across age group, gender, and ears.

(1987). Across all age groups, gender, and both ears, the mean TPP for the EHLS group was –23 daPa with a 90 percent range of –85 to 5 daPa. These data compare favorably with the mean (–16 daPa) and 90 percent range (–80 to 0 daPa) reported by Margolis and Heller for younger adults with normal middle-ear function. The negative mean pressure for both studies is expected, given the positive-to-negative direction of pressure change used in both experiments (Shanks and Wilson, 1986).

DISCUSSION

Age Effects

Peak Y_{tm} data from the present study support those earlier reports indicating that the middle-ear transmission system tends to stiffen with age. Although differences in mean peak Y_{tm} values for younger and older adults did not reach statistical significance, distributions of peak Y_{tm} values differed significantly for the two groups. Specifically, the peak and bottom tail of the distribution extended to lower values for the older adult group. Although other factors may be involved to some extent, the age difference for the two groups likely is the primary factor accounting for the differences in distributions.

Given the substantially larger sample size across age groups in the present study relative to earlier reports, direct comparisons of findings are limited. In addition, acoustic-immittance measures reported in some of the older studies were expressed in variables and units (e.g., compliance in cm^3) that are difficult to compare directly with measures obtained with current instrumentation. However, some general comparisons indicate selected similarities with earlier reports. Gates et al (1990, p. 251) reported that "the mean compliance decreased significantly with age..." from 60 to 94 years of age. Gates et al did not present their acoustic immittance data set, but reported that the "... mean compliance averaged across ears was 0.77 ± 0.010 mL, equivalent volume" (p. 251). This mean is higher than that observed in the present study, but it is difficult to compare means across the two studies, given the use of equivalent volume units in the Gates et al study. Although they used fewer subjects and less extensive age groupings, Jerger et al (1972), Blood and Greenberg (1977), and Hall (1979) also reported a decrease in Y_{tm} with increased age. It should be noted that, among these three studies,

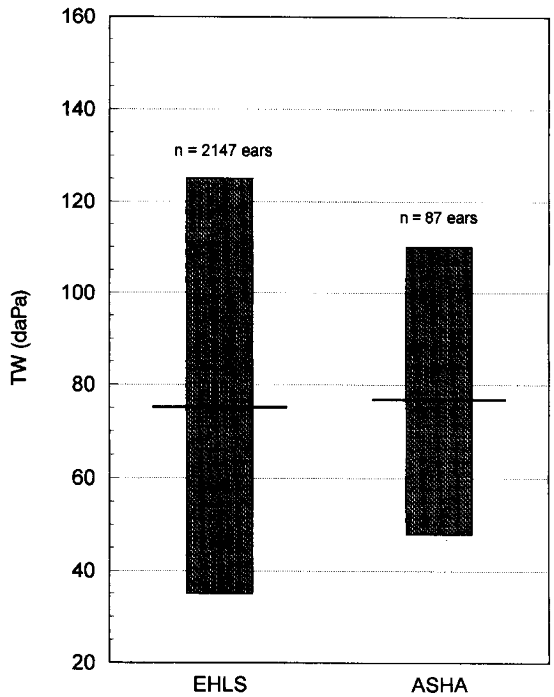

Figure 6 Mean TW values (lines) and 90 percent ranges (bars) for Margolis and Heller (1987) (ASHA, 1990) and the present (EHLS) study. EHLS data were combined across age group, gender, and ears.

only Blood and Greenberg (1977) provided any statistical analyses of their data for age effects.

As noted earlier, there was no significant difference in mean peak Y_{tm} values across younger (Margolis and Heller, 1987) and older (EHLS) adults, even though distributions of peak Y_{tm} values differed significantly for the two groups. Clinically, this suggests that the primary implication for screening and diagnostic applications of peak Y_{tm} measures in older adults is the need to extend downward the lower end of the 90 percent normal range.

Table 3 Tympanogram Peak Pressure Values for Margolis and Heller (1987) (ASHA, 1990) and for the Present (EHLS) Study

	TPP (daPa)			
	Mean	*Median*	*SD*	*90% Range*
ASHA (n = 87)	−16	−20	22	−80–0
EHLS 48–59 (n = 788)	−21	−15	29	−75–5
EHLS 60–69 (n = 636)	−24	−15	30	−90–5
EHLS 70–79 (n = 550)	−25	−15	35	−95–5
EHLS 80–90 (n = 173)	−21	−15	31	−80–5
EHLS ALL (n = 2,147)	−23	−15	31	−85–5

The EHLS data for each age group (in years) were combined across gender and ears. EHLS ALL represents data combined across age groups as well.

Results for older adults indicated that V_{ea} decreased and TW increased with advancing age. The increased TW with age is somewhat consistent with the decrease in Y_{tm}. Clinically, an increase in stiffness for the middle-ear transmission system reflected in a decreased Y_{tm} often is associated with an increase in TW. Indeed, that combination of findings is noted in the ASHA guidelines (1990) for screening middle-ear function. The observed decrease in V_{ea} with age for older adults in the present study, however, was somewhat unexpected based on the earlier report of Hall (1979). Although he provided no statistical analyses of his data, Hall (1979, p. 156) reported that "... equivalent volume of the external ear canal ... gradually increased with age" in male subjects over the range from 20 to 70 years of age and over. In women, Hall noted that V_{ea} "... remained relatively constant through age 70. Above 70 years of age, there was a dramatic increase" (p. 156). These reports are not entirely consistent with findings from the present study. V_{ea} values were larger for older adults in the present study than those reported for younger adults. However, for EHLS subjects ranging in age from 48 to 90 years, equivalent ear-canal volume tended to decrease with age, and the effect was observed for both females and males. Although a number of factors might account for this reversal in findings, the substantive difference in sample size for the present study and that of earlier studies is likely a primary issue. Also, it should be noted that the decrease in V_{ea} across the four older age groups in the present study was small relative to the larger difference in V_{ea} for younger and older adults. The clinical significance of the difference in V_{ea} for the older subjects is likely limited, then, particularly given the increased variability in measures for older adults. At the same time, any V_{ea} diagnostic criteria would have to account for the difference in V_{ea} measures for younger and older adults. Specifically, the upper end of normal variance (e.g., 90 percent normal range) in V_{ea} would have to be extended in diagnostic applications for perforations of the tympanic membrane in older adults.

The observed decrease in V_{ea} with advancing age in the present study is consistent with previous anatomic and clinical reports of ear-canal properties. Among ear-canal changes with advanced age that may have an effect on V_{ea} measures are reports of atrophic alterations in the walls of the external ear canal, increased prevalence of prolapsed ear canals, and increased hair growth in the ear canal (Hinchcliffe, 1962; Chandler, 1964). All of these conditions are consistent with decreases in ear-canal volume. Clinical studies in older adults also indicate that the prevalence of collapsing ear canals is considerably greater than that observed for younger adults (Schow and Goldbaum, 1980; Jerger and Jerger, 1981; Randolph and Schow, 1983). Jerger and Jerger (1981, p. 27) note that approximately one-third of patients over 65 years of age present collapsing ear canals. They note that these patients "... may have unusually small, narrow canal openings..." (p. 27). This narrowing or stenosis of the ear canal would be consistent with observed reductions in V_{ea} values. In the present study, subjects with otoscopically visible collapse (complete) of the ear canal were excluded from the data pool. However, it is possible that canal narrowing and/or partial canal collapse were present in a significant number of older subjects without complete collapse of the ear canal. This would be consistent with the smaller observed V_{ea} values in older adults and also would be consistent with the potential for a greater prevalence of collapsing ear canals in the same population.

Gender Effects

Overall, findings from the present study indicated that, relative to male counterparts, older females demonstrated lower peak Y_{tm} values, lower equivalent ear-canal volumes, and slightly wider TWs. Blood and Greenberg (1977) also noted that Y_{tm} was lower for older (under 70 years of age) females relative to their male counterparts. Similarly, Jerger et al (1972) reported lower Y_{tm} values for women relative to men over the age range from 20–80 years. In perhaps the largest sample reported, Gates et al (1990, p. 251) reported that there were no significant gender differences in "middle ear compliance" for their subject pool aged 60–94 years. Although Gates et al reported the results of their statistical analysis, they did not present their immittance data for comparison purposes.

The lower female V_{ea} is somewhat expected based on differences in auditory structural dimensions for adult females and males. Although we have no clear explanation for the slightly higher TW values in older females, the wider TW values are consistent with the lower observed Y_{tm} values mentioned earlier. Stiffer middle-ear systems associated with lower Y_{tm} values also often present higher TW values.

Clinical Implications

The present study was directed at clinical measures of middle-ear function in older adults. Results indicated clear differences in normative data for tympanometric screening measures in older adults and the same measures reported for younger adults. Relative to their younger adult counterparts, older adults demonstrated slightly lower peak Y_{tm} values, higher V_{ea} values, and somewhat narrower TWs. Further, these same measures varied as a function of age from 48–90 years, and our results indicated differences for male and female subjects. Finally, the variability for all measures was greater for the older adults relative to reported findings in young adults. The data displayed in Figures 4, 5, and 6 are means and 90 percent normal ranges for the three tympanometric measures in younger and older adults (combined across gender, age, and both ears). These data indicate clear differences in the lower and upper values of the 90 percent normal range for the two groups. If the 90 percent normal ranges for younger adults were used as referral criteria for older adults, there may be an unnecessarily large number of inappropriate referrals based on the three measures recommended by ASHA (1990). Of course, the actual test sensitivity and specificity of the measures and the eventual recommended measurement criteria for older adults would need to be determined through an evaluation of findings in older adults with confirmed middle-ear disorders. Overall, however, our findings indicate that tympanometric measures used in diagnostic protocols for older adults must account for age and gender differences.

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