ACOUSTICAL LETTER

Pure-tone audiometric thresholds of young and older adults

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1. Introduction

ISO 7029 [1] describes the expected amount of decline in the hearing sensitivity of otologically normal persons as a function of age. Estimation for audiometric frequencies of 125–8,000 Hz can be carried out separately for males and females. Although this Standard has been accepted widely as a reference for audiological evaluation, people in recent years apparently have a different auditory profile: they have better hearing ability at higher frequencies, particularly males [2].

In response to inference, the ISO/TC43/WG1 "threshold of hearing" set up a new project in 2005 to explore the possibility of updating ISO 7029. For revision, we first need to collect pure-tone audiometric threshold data in recent years from all possible subjects of different age groups and from different parts of the world.

The authors have conducted various psychoacoustic experiments at the National Institute of Advanced Industrial Science and Technology, Japan, adopting young and older adults as subjects. Before or after the main experiments, every listener participated in a pure-tone audiometric test. This test was conducted according to the standard procedure. Therefore, those accumulated data are useful for revision of ISO 7029.

This Letter is intended to present those audiometric threshold data obtained from young and older persons who had otologically normal hearing.

2. Pure-tone threshold measurement

2.1. Method

The monaural air-conduction threshold was measured with a pure-tone audiometer (AA-73 or AA-79S; Rion Co., Ltd.). These audiometers conformed respectively to JIS T 1201 [3] and JIS T 1201-1 [4], the latter of which is technically identical to ISO and IEC standards on audiometers [5,6]. Since these two audiometers adopted slightly different reference levels, the recorded data with the former audiometer were corrected to be equivalent to those with the latter audiometer. Measurement was carried out in a soundproof room whose background noise level was sufficiently low for threshold measurement and satisfied the criteria of ISO 8253-1 [7].

Threshold levels were measured using the bracketing method [7] for both ears separately. The test signal was an interrupted pure tone and was presented to subjects via an earphone. Test frequencies were of 125–8,000 Hz at one-octave intervals. The tone level was changed in 5-dB steps. Prior to the threshold measurement, otoscopic examination was made and obstructing wax in the ear canal was removed. Tympanometry and inquiry about difficulties in hearing were also conducted for each subject.

The younger subjects, aged below 30 years, were students of a high school or universities in Tsukuba. The older subjects were introduced by employment agencies of municipalities around Tsukuba. Table 1 shows the number of subjects in each age band, before and after the screening described below. They participated in measurements during the period of 1998–2005.

2.2. Results and discussion

Data from subjects who showed any of the following audiological abnormalities were excluded from the threshold calculation: (1) a middle ear pressure out of the range of ±50 daPa, (2) extensive exposure to loud sounds in the workplace or in daily life, (3) a history of a severe ear disease or injury, (4) familial hearing loss, or (5) an unbalanced threshold between left and right ears at any of the measured frequencies, the criterion being a threshold level difference of 30 dB or larger. Many elderly male participants, who were veterans of the Ground Self-Defense Force, were disqualified because of criterion (2).

Hearing threshold levels of both ears, in dB HL, were first averaged for every subject at each measurement frequency. Then the statistical indices of threshold level distribution were calculated for each age band. After screening, no subjects had immeasurable thresholds resulting from the limits of the audiometer. Table 2 summarizes the separate calculated values for males and females.

Figure 1 graphically represents median threshold levels with their interquartile ranges of age bands 20–29 and 60–69. In addition, it shows threshold data of two other studies [8,9] that were obtained in a comparable manner to that of the present study. For comparison purposes, the medians of age bands 62–64 and 67–69 in Ref. [8] were averaged to estimate the median of age band 60–69. As for Ref. [9], medians of two adjacent age bands were averaged because their data were stratified at five-year intervals: for example, the medians of age bands 60–64 and 65–69 were averaged to produce that of age band 60–69.

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Figure 1 shows that these measurements mutually agree well. Although males in their 60s in the present study exhibited lower hearing sensitivity, most individual data in these studies seem to overlap, as indicated by the interquartile ranges. The discrepancy among these studies becomes large for subjects in their 70s, about 10 dB for females and about 20 dB for males at some frequencies (not shown in Fig. 1). Those results might reflect the subjects being fewer than those of other age bands, giving a smaller sample size. For the same reason, the threshold values of subjects aged 80 and above in Table 1 should be evaluated with caution. Future studies should collect more data from people aged 70 and above to better record their average hearing ability.

Table 1 Subjects whose threshold levels were used for statistical evaluation. Parentheses enclose numbers of subjects before screening.

Age band (yrs.)	Males		Females	
15–19	23	(23)	30	(31)
20–29	81	(83)	54	(56)
60–69	21	(42)	24	(28)
70–79	21	(35)	27	(36)
80–89	6	(8)	4	(4)
Total	152	(191)	139	(155)

3. Concluding remarks

This Letter presented pure-tone audiometric thresholds of otologically normal persons of different ages. The average threshold values agreed well with those in two other studies for young subjects in their 20s and older subjects in their 60s.

Table 2 Hearing threshold levels in dB HL and their statistical indices of individual differences: (a) males and (b) females.

(a) Males

Age band (yrs.)	Frequency (Hz)																			
	125					250					500					1,000				
	P_{25}	Median	P_{75}	Mean	SD	P_{25}	Median	P_{75}	Mean	SD	P_{25}	Median	P_{75}	Mean	SD	P_{25}	Median	P_{75}	Mean	SD
15–19	4.0	6.5	9.0	6.7	4.9	2.9	5.4	7.9	6.2	4.7	1.5	4.0	6.5	4.2	4.5	1.0	2.5	6.0	3.2	3.3
20–29	6.5	9.0	11.5	8.8	4.5	5.4	7.9	12.9	9.2	5.3	4.0	6.5	11.5	7.4	4.7	2.5	5.0	8.5	4.8	3.6
60–69	14.0	19.0	21.5	19.1	7.6	10.4	17.9	25.4	17.8	7.8	11.5	16.5	24.0	17.3	7.9	11.0	16.0	21.0	16.5	8.9
70–79	16.5	21.5	29.0	22.5	9.3	15.4	20.4	35.4	23.9	11.0	16.5	24.0	29.0	24.7	8.7	16.0	31.0	36.0	27.9	12.8
80–89	30.9	37.8	40.9	36.5	10.4	27.9	29.2	39.8	32.9	10.4	19.6	24.0	35.9	26.9	12.4	21.6	23.5	23.5	26.0	11.4

Age band (yrs.)	Frequency (Hz)														
	2,000					4,000					8,000				
	P_{25}	Median	P_{75}	Mean	SD	P_{25}	Median	P_{75}	Mean	SD	P_{25}	Median	P_{75}	Mean	SD
15–19	0.6	3.1	5.6	3.3	3.4	−1.3	1.2	3.7	1.4	4.5	−1.3	1.2	6.2	2.6	4.9
20–29	0.6	5.6	8.1	4.7	4.2	1.2	3.7	6.2	4.2	5.0	−1.3	3.7	8.7	3.3	6.2
60–69	15.6	23.1	35.6	24.3	10.6	23.7	36.2	46.2	35.7	13.1	38.7	51.2	61.2	49.9	14.5
70–79	20.6	38.1	48.1	36.1	14.5	46.2	58.7	61.2	53.0	14.1	53.7	68.7	73.7	62.9	14.4
80–89	33.7	50.6	52.5	43.1	14.8	53.7	63.7	68.1	61.6	11.2	65.0	70.0	73.1	70.8	7.5

(b) Females

Age band (yrs.)	Frequency (Hz)																			
	125					250					500					1,000				
	P_{25}	Median	P_{75}	Mean	SD	P_{25}	Median	P_{75}	Mean	SD	P_{25}	Median	P_{75}	Mean	SD	P_{25}	Median	P_{75}	Mean	SD
15–19	6.5	9.0	13.4	9.4	4.9	5.4	10.2	12.9	9.1	4.9	4.6	6.5	9.0	6.9	4.5	1.0	3.5	5.8	2.3	3.3
20–29	4.0	9.0	13.4	9.0	6.0	5.4	7.9	12.9	9.5	6.0	4.3	6.5	9.0	7.2	5.1	1.0	3.5	6.0	4.1	5.4
60–69	18.4	21.5	26.5	22.3	7.3	17.9	20.4	24.2	21.4	7.5	14.0	20.3	27.1	20.7	8.0	10.4	13.5	21.0	17.5	10.4
70–79	16.5	19.0	27.8	22.7	9.4	15.4	17.9	25.4	20.9	9.7	11.5	16.5	24.0	19.2	10.5	14.8	21.0	23.5	21.7	13.1
80–89	15.3	22.8	35.9	28.4	20.1	19.8	27.9	39.8	31.7	21.3	25.3	29.0	36.5	32.8	18.9	21.0	27.3	34.1	27.9	18.4

Age band (yrs.)	Frequency (Hz)														
	2,000					4,000					8,000				
	P_{25}	Median	P_{75}	Mean	SD	P_{25}	Median	P_{75}	Mean	SD	P_{25}	Median	P_{75}	Mean	SD
15–19	−1.4	1.9	5.6	2.8	4.1	−3.2	1.2	3.7	0.2	4.7	1.2	3.7	10.0	5.6	5.4
20–29	0.6	3.1	5.6	3.8	4.5	−1.3	1.9	6.2	2.8	5.0	1.2	5.0	8.7	4.5	7.6
60–69	12.5	19.4	28.1	20.6	12.0	15.6	20.0	30.0	24.5	15.9	28.7	36.2	51.2	39.2	19.8
70–79	18.1	23.1	31.9	26.6	12.7	26.2	33.7	42.5	34.6	15.1	37.5	53.7	68.7	52.4	20.0
80–89	29.4	35.6	40.6	34.4	12.5	31.2	36.2	44.3	39.3	15.9	65.6	68.7	74.3	71.2	8.9

P_x: *x*th percentile SD: standard deviation in dB

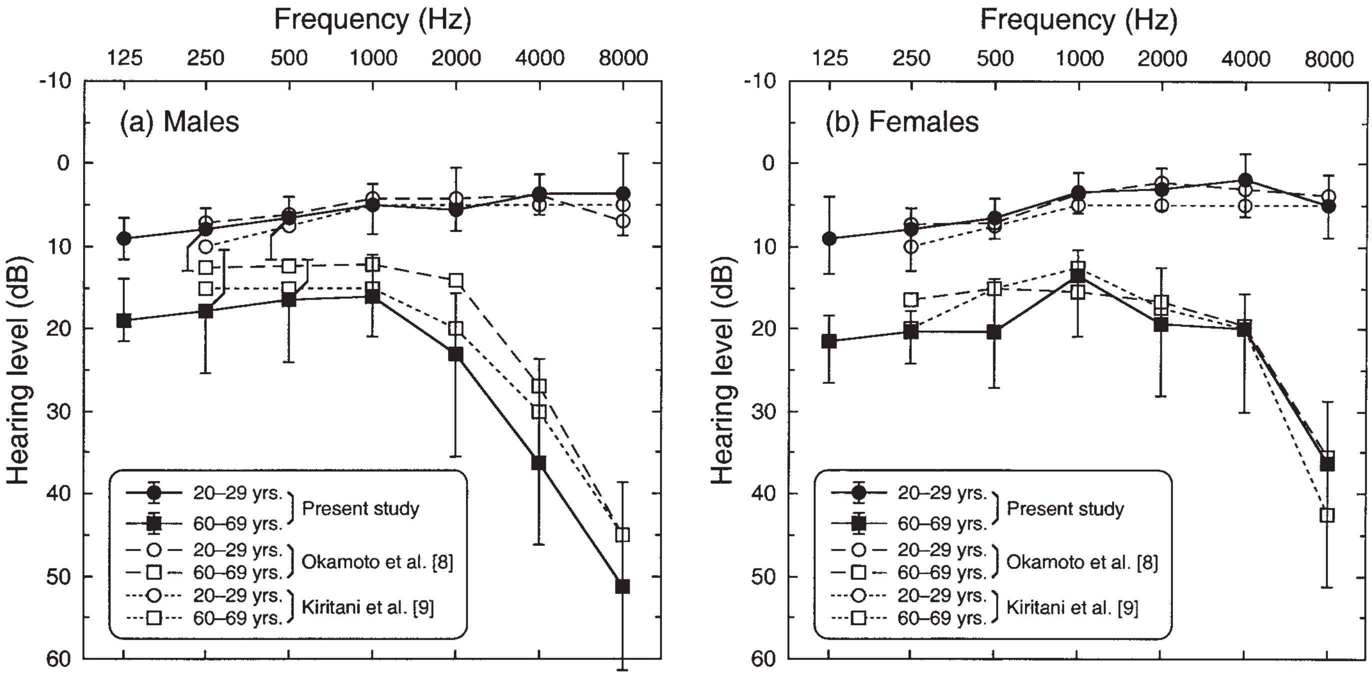

Fig. 1 Graphical representation of median hearing threshold levels of two selected age bands. Error bars indicate the interquartile range (i.e., the interval between the 75th and 25th percentiles). Threshold values of two other studies [8,9] are also shown for comparison.

The present measurement results support the finding in the earlier report [2] that the Japanese in recent years have better hearing sensitivity than that described in ISO 7029.

ISO 7029 expresses the age-related hearing sensitivity decline as deviation from the threshold of 18-year-old people. Although several studies of aging effects on the hearing threshold have been published in Japan, most of those studies examined subjects aged 20 and above. They allow no direct comparison of threshold levels among subjects in their late teens and of other ages. Table 2 shows that subjects in their late teens have slightly better hearing ability on average than those in their 20s. Consequently, collecting data from people in their late teens, as performed in the present study, is important for future revision of the Standard.

References

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