Reexamination of the age-related sensitivity decrease in ISO 7029: Do the Japanese have better hearing sensitivity?

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(Received 1 February 2005, Accepted for publication 17 February 2005)

Keywords: Hearing sensitivity, Audiometry, Hearing threshold level, Aging effect, ISO standard

PACS number: 43.15.+s, 43.66.Cb, 43.66.Sr [DOI: 10.1250/ast.26.381]

1. Introduction

Our hearing sensitivity to tones of various frequencies declines progressively as we become older. ISO 7029 [1] describes a method for calculating expected median values of hearing thresholds and the expected statistical distribution around the median. Such calculation is possible for audiometric frequencies of 125–8,000 Hz. The target population is otologically normal persons aged 18–70 years inclusive. This standard is based on an extensive survey by Robinson and Sutton [2] and a supplementary formulation by Shipton [3]. The former investigated audiometric data in 25 studies and finally adopted those in seven papers published from 1959 to 1970.

However, more than 30 years have passed since the ISO standard source data were published. During those decades, we, living in an industrialized country, have experienced changes that may have affected our hearing ability: hearing-conservation actions have been taken, especially in the workplace. Sanitary and nutritional conditions have also improved. Adverse effects of World War II have diminished in most countries including Japan. Therefore, we may display a different profile of hearing sensitivity than that shown in the ISO standard.

This Letter is intended to review the ISO threshold values of different ages, comparing them to Japanese data published after the Robinson and Sutton survey. A revision of the ISO standard is proposed based on the results of comparison.

2. Comparison of Japanese hearing-threshold data to ISO standard values

Audiometric data reported in two Japanese studies were employed for comparison: Okamoto et al. [4] and Kiritani et al. [5]. They are comparable to ISO 7029 in that: (1) the subjects showed no obvious symptoms of ear disease; (2) the subjects represented a wide range of ages — 20–70 and over; and (3) medians of hearing threshold levels were reported. Table 1 summarizes the numbers of subjects in each age band selected for the comparison. Although both ears were tested, threshold levels of the better ear were reported in Okamoto et al. and left-and-right averages in Kiritani et al.

The ISO standard value is expressed as a hearing threshold deviation, ΔH_{md,Y}, in dB: the increase of the median hearing threshold level from that of the reference age (18 years old). For purposes of comparison, the Japanese threshold data in those two studies were transformed as follows. The hearing threshold deviation of the youngest age band, ΔH_{md,y,youngest}, was calculated first, using the equation in ISO 7029: the age band of 25 years in the case of Okamoto et al. and 22.5 years in Kiritani et al. Then, the difference of the hearing threshold level between the youngest age band, H_{md,y,youngest}, and an older age band, H_{md,Y,older}, was added to ΔH_{md,y,youngest} to obtain a deviation value for each older age band as

\[ ΔH_{md,Y} = ΔH_{md,y,youngest} + (H_{md,Y,older} - H_{md,25}), \]

for Okamoto et al.,

\[ ΔH_{md,Y} = ΔH_{md,y,youngest} + (H_{md,Y,older} - H_{md,22.5}), \]

for Kiritani et al.

These calculations were conducted separately for male and female subjects.

Results of those calculations are represented graphically in Fig. 1: panels (a) and (b) for male subjects and panels (c) and (d) for female subjects. Panels (a) and (b) indicate that Japanese male subjects in both studies generally show smaller threshold deviations than the ISO expected values. That discrepancy tends to be larger for higher frequencies, being 10 dB or more in some cases. Female subjects in panels (c) and (d) also show a similar tendency, but the discrepancy is not as large as that for male subjects. The 68.5-year-old band of Okamoto et al. has higher thresholds than standard values. However, that may be caused by large threshold variations among the small number of subjects in that age band, as suggested by the partially reversed relation of the threshold deviations to those of the 75-year-old band.

These results indicate that the Japanese people in recent years show, on average, a smaller age-related decrease in hearing sensitivity than people did more than 30 years ago. That change might be attributable to the social factors mentioned in the Introduction. In fact, Fig. 1 shows that the discrepancy becomes greatest at 4,000 Hz in many cases, not at the highest frequency of 8,000 Hz. The higher thresholds in the ISO standard seem to be influenced by noise-induced hearing loss, possibly because of noise exposure in the workplace. That would also explain why the improvement of, or rather, the marked conservation of, hearing ability was observed for male subjects.
Table 1  Number of subjects in Japanese studies used for comparison.

<table>
<thead>
<tr>
<th>Middle of age band (yr.)</th>
<th>25</th>
<th>48.5</th>
<th>58.5</th>
<th>68.5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Okamoto et al. [4]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>52</td>
<td>111</td>
<td>133</td>
<td>46</td>
<td>342</td>
</tr>
<tr>
<td>Females</td>
<td>25</td>
<td>102</td>
<td>77</td>
<td>22</td>
<td>226</td>
</tr>
<tr>
<td>Kiritani et al. [5]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>693</td>
<td>795</td>
<td>577</td>
<td>93</td>
<td>2158</td>
</tr>
<tr>
<td>Females</td>
<td>100</td>
<td>222</td>
<td>133</td>
<td>41</td>
<td>496</td>
</tr>
</tbody>
</table>

Fig. 1  Comparison of median hearing threshold deviations of Japanese subjects with those of the ISO standard [1].
(a) Males in Okamoto et al. [4], (b) males in Kiritani et al. [5], (c) females in Okamoto et al., and (d) females in Kiritani et al. Note that the threshold deviation increases downward, as in the conventional audiogram.
3. Concluding remarks

The above mentioned social changes that have favorably affected our hearing have probably occurred among many industrialized countries. Higher hearing sensitivity in the older population is likely to be found not only among the Japanese but also among people in other countries. If such is the case, the ISO standard should be updated by incorporating the latest measurement data, which would serve as a better reference for hearing-ability evaluations.

Another conspicuous social change in recent years is prolonged life expectancy. The average life expectancy of women has become greater than 80 years in many countries, including Japan. Although the calculation method of ISO 7029 is applicable up to the age of 70, recently published reports on hearing such as Refs. [4,5] embrace a wider range of subjects’ ages. Extension to higher ages would be beneficial to users of that standard.

References