A Large-Scale Study of Auditory Function in Diabetic Veterans

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Introduction

Diabetes mellitus is one of the most common and serious chronic diseases in the United States. About 13 million Americans have diabetes. Each year, approximately 1.3 million people are diagnosed with diabetes. The prevalence of diabetes has increased steadily in the last half of this century and will continue to rise with the aging U.S. population, the growth in minority populations most susceptible to type 2 diabetes, and the increasing prevalence of obesity among Americans.

Diabetes has many serious pathological effects on various organs of the body. Auditory complications associated with diabetes have not been well documented. The Department of Veterans Affairs National Center for Rehabilitative Auditory Research (NCRAR) is currently conducting a five-year epidemiological study to assess the prevalence and severity of auditory dysfunction in veterans with diabetes using a battery of audiometric tests.

Study Design

Participants are veterans with and without diabetes who are matched as nearly as possible for age and hearing loss. Ages range from 25 to 85 years. The diabetic participants must have been diagnosed for at least five years. Participants receive a modest payment for their 4 to 5 hour session in our laboratory. The test session includes breaks to relieve test fatigue.

Audiometric and questionnaire data were obtained on 342 diabetic and 352 non-diabetic veterans. Each participant's glucose levels and HbA1C were tested to provide a measure of metabolic control over the past three months. A test of peripheral neuropathy (the Quantitative Sensory Test) was also administered using the CASE IV instrument to measure cooling and vibration sensitivity as indicators of peripheral neuropathy.

Results

Demographic and Clinical Characteristics

Mean ages of diabetic and non-diabetic veterans were 61.7 (SD = 9.8) and 62.9 (SD = 11.3) years respectively. Average duration of diabetes from diagnosis to time of test was 12.5 years (SD = 8.2). Forty-three percent of the diabetic patients were taking insulin to manage their disease. The others either were taking oral medications or were attempting to control their diabetes by diet. In diabetic patients for whom laboratory data were available, forty-three percent (138) had kidney problems and thirty-five percent (83) had vision problems of varying degrees related to diabetes. All participants were tested for glucose and HbA1C levels and for cooling and vibration sensitivity at the begining of the session. Table 1 shows clinical characteristics of both groups.

Table 1. Means and standard deviations of glucose level (mg/dl), HbA1C (%), and cooling and vibration thresholds (jnd's) for diabetic and non-diabetic groups.

	Diabetic	Non-diabetic
Glucose	210.6 (82.1)	104.4 (18.7)
HbA1C	7.88 (1.5)	5.48 (.6)
Cooling jnd	15.6 (5.9)	13.7 (5.6)
Vibration jnd	21.2 (3.4)	19.7 (3.3)

Pure Tone Thresholds

Pure tone thresholds were obtained at octave frequencies (and interoctaves where appropriate) from 250 to 8000 Hz, and at 10, 12.5, 14, and 16 kHz using a Madsen Orbiter 922 with ER-3A insert earphones. No significant differences in average thresholds were found between diabetic and non-diabetic groups.

- **Duration:** Thresholds at 8000 Hz and above were significantly correlated with duration of disease.
- **Age:** When each group was divided into two age groups at the 60 year-old mark, diabetic veterans 60 years old and younger had significantly poorer average thresholds than non-diabetic patients in the same age group. Diabetic patients over 60 years old had poorer thresholds at only two ultra-audiometric frequencies (10 and 12.5 kHz). Figure 1 displays pure tone thresholds for right and left ears by age group.
- **Noise Exposure:** Self report of noise exposure was obtained for military, recreational and occupational noise. Crosstabulations did not indicate any significant difference in frequency of the three types of exposure between diabetic and non-diabetics in either of the two age groups.
- **Insulin:** There is a tendency for the diabetic patients taking insulin to have poorer thresholds than those without insulin in the under 60 year-olds, but in the group over 60 insulin has no effect.
- **HbA1C:** Diabetic veterans under 60 years old had significantly better pure tone thresholds when the HbA1C was higher than the median value (7.7%) than those whose HbA1C was lower.

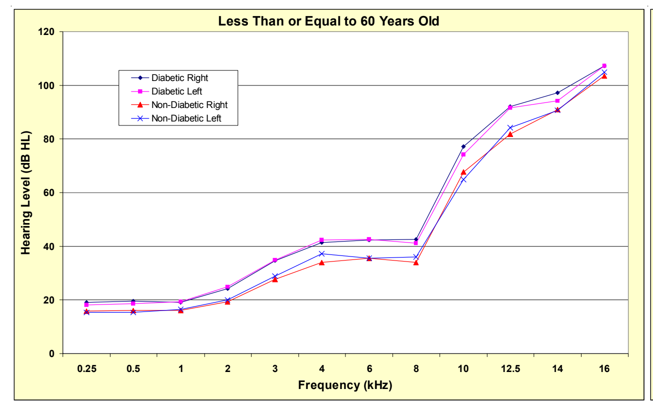


Figure 1. Pure tone thresholds for diabetic and non-diabetic veterans 60 years old or less.

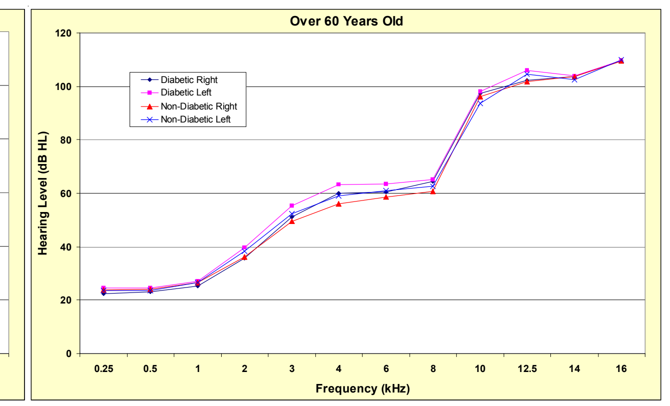


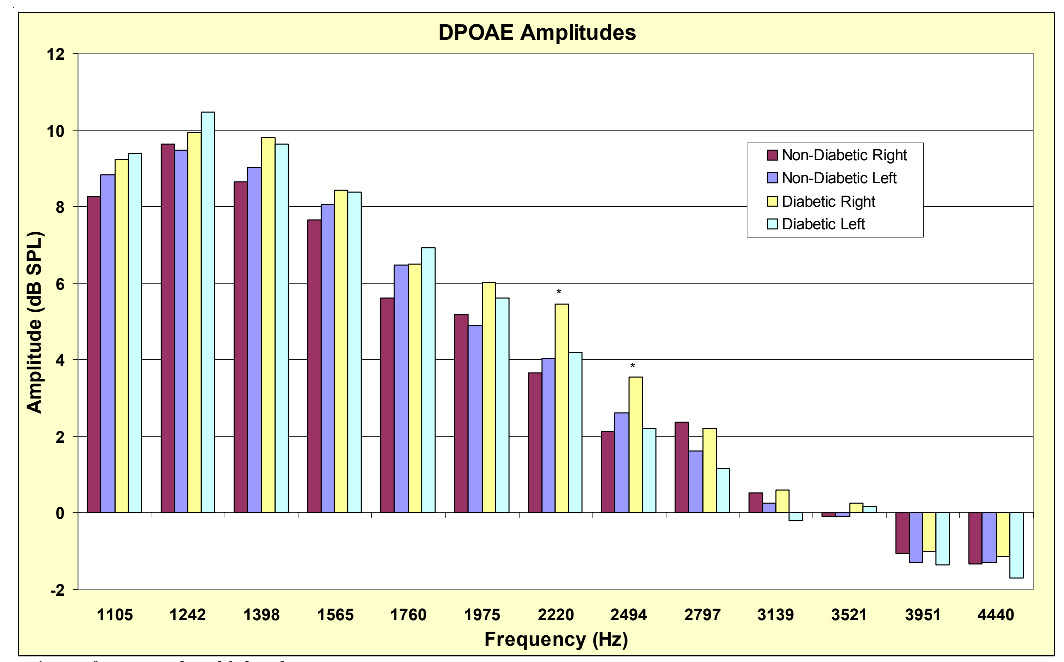
Figure 2. Pure tone thresholds for diabetic and non-diabetic veterans over 60 years old.

Otoacoustic Emissions

Distortion product otoacoustic emissions (DPOAE)) were considered valid only if the signal-to-noise ratio (SNR) was greater than 6 dB, and the distortion product (DP) amplitude was greater than -5.0 dB SPL. Valid OAE distortion products were obtained at one-sixth octave frequencies between 1000 Hz and 5000 Hz. The data reported here were obtained at 65 dB with 16 acceptable sweeps per frequency.

Figure 3 shows average amplitudes of DP responses in each ear for both gorups. Only DP amplitudes at 2220 and 2494 Hz in the right ear were statistically different between groups. However, the differences over all were small , and amplitudes tended to be higher in diabetic than in non-diabetic patients (Figure 3).

- **Age:** When the groups were divided by age (as above), the small differences in amplitudes at two frequencies were found only in veterans over 60 years of age.



*significant at the .01 level

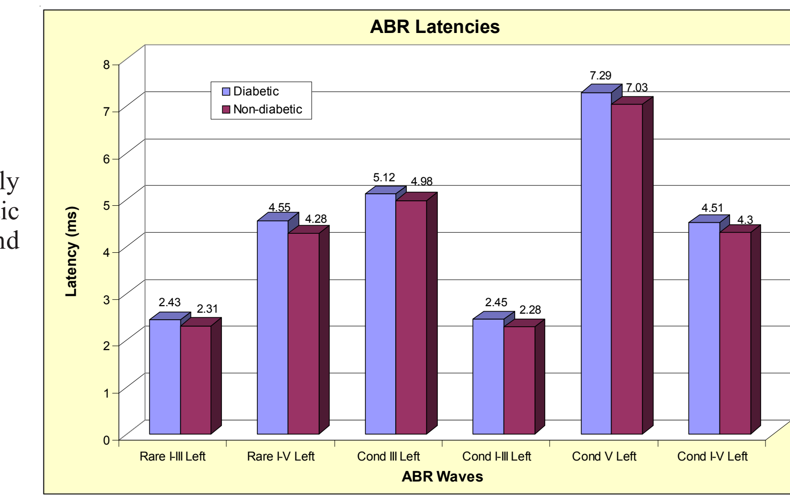
Figure 3. Distortion product amplitudes for diabetic and non-diabetic veterans by ear for sixth-octave frequencies from 1105 to 4440 Hz.

Auditory Brainstem Response Test Results

Latencies were significantly longer for Waves III and V and interpeak latencies I-III and I-V were significantly delayed in diabetic compared to non-diabetic patients when condensation clicks were presented at 90 dB nHL through ER-2 insert earphones. The same interpeak latencies were delayed in the diabetic group also with rarefaction clicks. Figure 4 shows the latency data.

- **Duration:** ABR latencies were not correlated with duration of the disease.
- **Hearing Loss:** Thresholds at all frequencies (250 Hz through 16 kHz) are highly correlated with both absolute and interpeak latencies in non-diabetic patients. In diabetic patients, absolute latencies of waves III and V were correlated only with 2 and 3 kHz. These results suggest that variables other than hearing loss are responsible for the latency delays in diabetic ABR's.
- **Age:** Age was correlated with absolute and interpeak latencies in the non-diabetic group, but age was not associated with latencies in diabetic patients.
- **Insulin:** There was no significant difference in absolute or interwave latencies between diabetic patients who were and those who were not using insulin.
- **HbA1C:** HbA1C is not significantly correlated with ABR latencies in either group.

Figure 4. Latencies that are significantly longer in diabetic compared to non-diabetic patients obtained with condensation and rarefaction polarity clicks at 90 dB nHL.



- **Waveform Morphology:** Poor waveform morphology, defined here as unidentifiable wave V, occurred in 45% of non-diabetic patients and in 50% of diabetic patients. Within the non-diabetic group, those with poor waveform morphology were older and had, on average, 16 dB poorer thresholds at 2000, 3000, and 4000 Hz. Although there were no differences in hearing loss or age related to waveform morphology within the diabetic group, diabetic patients with poor waveform morphology were, on average, 4.4 years younger than those in the non-diabetic group.

Threshold Differences	Non-diabetic	Diabetic
2000 Hz	16.3*	4.8**
3000 Hz	16.0*	5.7***
4000 Hz	15.0*	3.0

*p=.000, **p=.049, ***p=.035

Table 2. Mean differences in thresholds (dB HL) at 2000, 3000 and 4000 Hz associated with present versus absent Wave V in diabetic and non-diabetic patients.

Discussion

The NCRAR study reported here is the largest prospective study of diabetes and auditory function to date (n=694). Our preliminary analyses indicate that central auditory functions are affected by diabetes to a greater extent than peripheral functions. The prolongation of absolute latencies of waves III and V and of the interwave intervals I-III and I-V suggest that the central transmission times were delayed in the early brainstem pathway. Martini et al. (1987) also found an effect of diabetes on central transmission times (I-V).

Age and hearing loss were associated with ABR latencies in non-diabetic but not in diabetic patients. These data, combined with our findings that poor waveform morphology in diabetic patients is not affected by age and hearing loss, point to a potential role of diabetic mechanisms in auditory brainstem pathology. The absence of a delayed Wave I does not support the presence of pathology affecting peripheral transmission time from the pre-neural functions of the cochlea to the auditory nerve.

When the two groups were compared, there were no significant differences in pure tone thresholds. Dividing our groups into age subgroups, we found that the younger group of diabetic patients (<60 years old) had greater hearing loss than their non-diabetic controls, but average pure tone thresholds were similar in the over 60 year olds in both groups. In older diabetic patients, changes in hearing sensitivity due to diabetes may be obscured by presbycusis.

Our findings to date tend to support the theory that diabetes is associated with accelerated aging of the auditory system (Biessels et al., 2002; Kent, 1976). Hearing loss was greater in the diabetic group under 60 years old and poor waveform morphology is present at a younger age in diabetic than in non-diabetic patients. These results indicate that it may be appropriate to conduct ABR and pure tone testing early in diabetic care. Further analyses of our data will examine the effects of diabetic mechanisms such as microvascular and neuropathic complications on the auditory measures reported here.

References

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