

DPOAE MEASUREMENTS IN FACTORY WORKERS WITH COCHLEAR HEARING LOSS

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The main aim of the study was to find a correlation between the pure-tone threshold measured by a classic audiometer and estimated from input/output function of distortion product otoacoustic emission. The measurements were performed for a group of 27 factory workers and a control group of 10 young subjects with normal hearing (YNH). The interrelations between the results of these two methods were analyzed with respect to all measured frequencies and for six groups of subjects representing different characteristics of audiograms. The UCL (uncomfortable level) influence on I/O-functions was also considered.

Key words: otoacoustic emission, audiogram.

1. Introduction

There are a few basic methods to estimate a hearing loss, such as: subjective – tonal audiometry and objective – DPOAE (Distortion Product Otoacoustic Emission). DPOAE has gained popularity as a clinical test for hearing screening and diagnostic purposes. GORGA *et al.* [2] suggested that the audiometric threshold could be predicted from DPOAEs and BOEGE, JANSSEN [1] found that there was a significant correlation between the hearing threshold estimated on the basis of DPOAE and the pure-tone threshold. However, not all authors have got a high correlation, suggesting that it depends on the number of the subjects studied, the more numerous the group of subjects the better the correlation. This method of examination would be very suitable to determine the hearing thresholds in the people for whom it is impossible to do it in the classical way.

2. Experimental method

The experiment was undertaken to test the usefulness of the pure-tone threshold determination from the input/output functions of distortion product otoacoustic emission, proposed as a method for assessment of hearing loss by BOEGE and JANSSEN [1] in confrontation with the results obtained by the classical method. The subjects were the factory workers exposed to high level of noise for a few hours at work expected to have developed various hearing impairments and the results obtained for them were

compared with those of a control group of young normal hearing listeners (YNH). The effect of UCL (uncomfortable level) on I/O-functions was also analysed. The measurements of $2f_1 - f_2$ DPOAE was performed at 19 frequencies between $f_2 = 504$ and 11309 Hz (with a constant f_2/f_1 ratio ($f_2 > f_1$) of 1.22) and for three levels of two-tone: 85/75, 75/65 and 65/55 dB SPL. The I/O functions were determined at the frequencies 2, 4, 6, 8 kHz and in a wide range of primary tone levels (45–90 dB SPL) so that it would be possible to apply them for the hearing threshold prediction. DPOAE pressure I/O-functions were constructed by plotting p_{dp} (the pressure of the $2f_1 - f_2$ distortion product) against the primary tone level L_2 . The extrapolating regression line towards $p_{dp} = 0$ yields the estimated hearing threshold for L_2 (Fig. 1). The extrapolated values were compared with those obtained from the classical pure-tone audiogram [1, 3] and a correlation between them was checked.

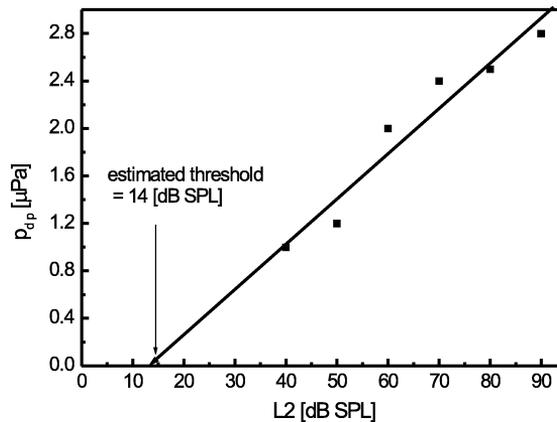


Fig. 1. The linear fitting procedure for estimating threshold.

3. Subjects and apparatus

Twenty-seven factory workers with various hearing loss and ten young normal-hearing subjects participated in this experiment. From among ears with hearing loss there were 49 without and 5 with tinnitus. Hearing losses ranged from slight (20 dB HL) to severe (100 dB HL). All subjects were younger than 56 years (to minimize effect of presbycusis) and had been working at the tram factory for 5–25 years over 5–6 days a week. None of the subjects reported any otological history such as ear infection and ototoxic drugs, but all of them were exposed to noise. Data were collected for both ears of every subject.

Threshold stimuli were presented by Senheiser HD 300 headphones connected to the Audiometer GSI-61. DPOAE measurements were performed by Audera GSI.

4. Results and discussion

Each subject was characterized by the hearing threshold, DP-gram and input-output function of otoacoustic emission, but the comparison was made for the results obtained

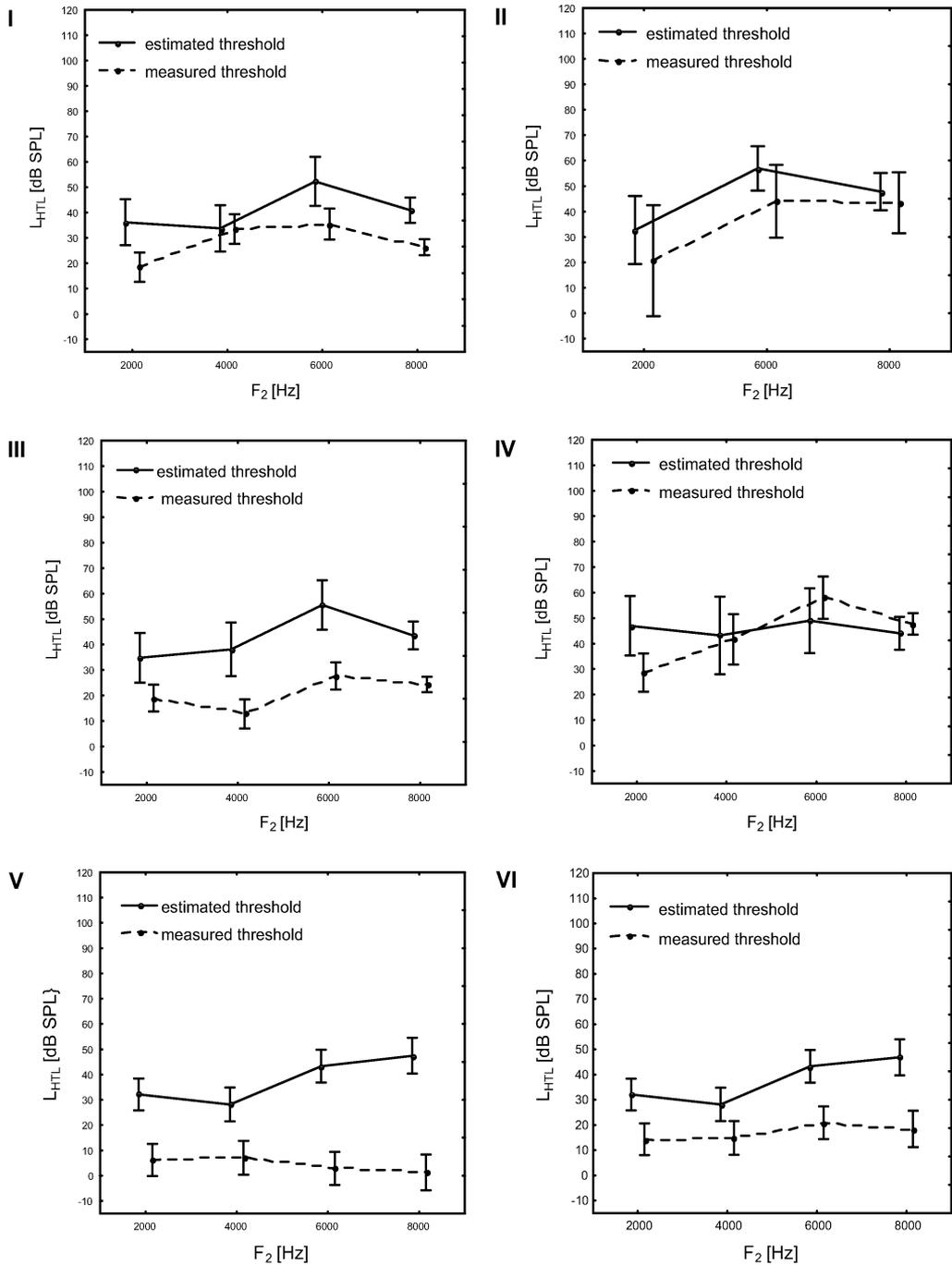


Fig. 2. Comparison between hearing thresholds measured by the classic audiometry and estimated from input/output functions of distortion product otoacoustic emission L_{HTL} [dB SPL] versus frequency [Hz]. Results are presented for factory workers in groups I-IV representing different types of hearing loss and two groups of normal hearing subjects (V – factory workers, VI – control group).

at the first and third examinations. The choice of these results followed from the fact that the input-output function was obtained for more primary tone levels (45–90 dB SPL) than DP-grams ($L2$: 65–85 dB SPL), therefore more values were taken to linear regression.

To compare the measured and estimated thresholds (for 2, 4, 6 and 8 kHz), all subjects were split into six groups according to the type of hearing loss. In Fig. 2 the hearing thresholds obtained by the two methods for six different groups of subjects are plotted as a function of frequency.

The interrelation between the results obtained by the two methods was analyzed with respect to all measured frequencies. The subjects in groups I–IV were diagnosed with cochlear hearing damage caused by noise, group V were the factory workers without any hearing loss and the last was the control group of young normal hearing listeners (YNH). Seven ears were not included in the analysis because of undetectable otoemission.

Assuming the significance level of 0.05 the frequency was differentiating factor for groups I, II, III, IV, however in group I statistical difference was found only for 6 kHz. No significant differences were found in the results obtained by the two methods for groups: I [$F(1, 40) = 0.14, p > 0.05$], II [$F(1, 30) = 3.35, p > 0.05$], IV [$F(1, 120) = 0.25, p > 0.05$]. Despite the fact that there were significant differences in the results obtained by the two methods used in the experiment for the control group of YNH [$F(1, 152) = 73.28, p < 0.05$], the tendencies of the curves obtained by these methods were alike [$F(1, 48) = 1.73, p > 0.05$].

The ANOVA was used to examine the influence of seniority (understood as the time one has performed a given job) and kind of the job on the hearing threshold. Both factors were statistically significant [$F(4, 811) = 37.28, p < 0.05$ and $F(3, 811) = 5.27, p < 0.05$].

The effect of UCL on the I/O-functions for the factory workers without any hearing loss was noticed (group V). The lower the uncomfortable level the higher the value of the primary tone level at which the I/O-function began to be nonlinear (the saturation effect). As high values of the uncomfortable level (UCL) were found for the majority of the subjects, the UCL value can be a significant factor influencing the experimental results.

5. Conclusions

The data collected in this experiment suggest that the estimated (from DPOAE pressure I/O-functions) and measured hearing threshold values cannot be directly compared, however, there are some interdependences between the threshold values obtained by these two methods. The only information provided by the threshold estimated in this procedure can be rather qualitative than quantitative.

As for some groups the results were found to be in agreement, it seems purposeful to undertake a more detail investigation of the effect of the type of hearing loss on the effectiveness of the hearing threshold determination by acoustic otoemission. The fact that not all DPOAE threshold estimations yield a close correspondence to the pure-

tone threshold can be explained by the involvement of some factors influencing the character of otoemission (such as low value of uncomfortable level), whose effect has to be investigated. It should be noted that the acoustic otoemission may not occur at all even in the persons with a normal hearing threshold determined by the classical tonal audiometry (< 20 dB HL).

Results of this study show that the ability direct prediction of the pure-tone threshold by means of extrapolated DPOAE I/O-functions seems to be insufficient to improve the clinical potential of DPOAEs, because there might be other sources of hearing impairment as inner hair cell or retrocochlear damage.

Acknowledgments

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