THE HEARING THRESHOLD IN UNIVERSITY-AGED STUDENTS

Smagowska Bozena

Central Institute for Labour Protection – National Research Institute, Warsaw, Poland

e-mail: bosma@ciop.pl

This paper includes the results of measurement hearing threshold of students from different universities in Warsaw. The hearing threshold was measured using conventional air pure tone audiometry, without the assessment of perception loudness, pitch and time. Tests of hearing loss in both ears were carried out in the low frequency range from 125 Hz to 8000 Hz (176 subjects) and in the high frequency range from 10 kHz to 16 kHz (41 subjects). Sound Pressure Level of test signal was controlled automatically according to Hughson - Westlake technique. The results of the hearing threshold were classified depend on the hearing loss value in the three ranges: 10 dB - 20 dB, 20 dB -30 dB and over 30 dB for both frequency ranges. The results show that 73% of all subjects in the low frequency range have small hearing loss (up to 20 dB) and 22% of all listeners have small hearing loss in the high frequency range. 23% of all subjects in the low frequency range have the average hearing loss (from 20 dB to 30 dB) and 37% of all listeners have average hearing loss in the high frequency range. 4% of subjects in the low frequency have big hearing loss (over 30 dB) and 41% of listeners have big hearing loss in the high frequency range. The recruitment of student for tests was made on a voluntary basis.

1. Introduction

Results of hearing threshold test of different groups: children, teenagers as well as university students, indicates that hearing loss appear more often nowadays, than in the past decades. This is very often an effect of an excessive exposure to high sounds from music players with headphones and sound systems in the cars or home, as well as an exposure to high levels music on the pop/rock concerts (especially heavy metal ones) and parties in clubs\textsuperscript{1,2,3}. Hearing loss (difference between measured value and middle hearing threshold obtained for normally hearing people) is defined by marking dependency sound pressure level on frequency. Hearing loss may be temporary (TTS - Temporary Threshold Shift) or permanent (PTS - Permanent Threshold shift)\textsuperscript{4,5,6}.

Temporary Threshold Shift (TTS) appears as an effect of hearing fatigue that comes from being under the influence of activity of strong sounds stimuli and it subside after long time (even after a few days) from the end of simulation moment\textsuperscript{6,7}. Permanent Threshold shift (PTS) is in case permanent auditory cells damaged\textsuperscript{6,7}.

Hearing damage cause a lot disorders, among others difficulty speaking (disorder to understand in noisy environment) diminishment of sound location (disorder of space orientation) and recognition of warning sound. Effects of hearing damage have adverse influence on quality of life and possibility to work (potential sources of income).
Hearing damage of people working not only in this places like: television, cinematography, radio station (sound operator) as well in the trade, telecommunications, the automotive industry, make difficulties in working in above mentioned fields, or are the stress factor when noticed by the people around (orchestra conductor or musician). It can turn out an impediment for people who would like to get a place on the specialist courses (eq. sound direction). One of the measures of the proper operation of the hearing organ, determining its sensitivity, is the data defining the threshold of audibility in the form of an audiogram.

This paper consist hearing condition assessment of 176 people sample population of students from different universities in Warsaw. This assessment includes measure threshold results using conventional air pure tone audiometry, without the assessment of perception loudness, pitch and time. Students had survey about: experienced an illness (special otopathy, ear infection) to take oto-toxic medicament (special antibiotics) and earlier exposure to high sound pressure levels (special acoustics trauma). The aim of this test was to choose people with good hearing, for participating in next study were audiometric criterion was health condition8,9.

2. Apparatus and procedure

Student recruitment for measuring was proceeded on the voluntary rule and participants didn’t have money. Before test, each student was informing about measure method. Next each students had exercises to aim familiarize with the procedure of test and way of giving a signal. Headphones TDH39P placed in Peltor earpiece were used in the low frequency range and headphones Koss HV Pro with circumaural cushions in the high frequency.

Hearing threshold results was measured using conventional air pure tone audiometry at special test stand which consists of standard acoustic refuge and audiometer Interacoustics AC40. During measure acoustic condition inside of acoustic refuge (sound pressure level – 30 dB) and high attenuation of circumaural earphone made possible determine threshold level for people with audible -10dB. Air conduction pure tone audiometry was used for 11 standard frequencies ie. 0.125, 0.250, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 i 8.0 kHz in the low frequency range and at three frequencies in the high frequency range. Hearing test was started from right ear. Sound Pressure Level of test signal was controlled automatically according to Hughson - Westlake technique (according standard ISO 8253) with 5 dB step level control10,11.

According to this method, first the hearing threshold value for air conduction pure tone audiometry is determined in 1000 Hz. Next, frequency is changed to take turns 2, 4, 8, 10 kHz and again 1 kHz (control measure). Further measure is determining consecutive hearing threshold value to carry out in the low frequencies 125, 250 i 500Hz and in the high frequency range 10.0, 12.5, i 16.0 kHz. Hearing loss \( U_s \) (for air conduction pure tone audiometry) is determine as difference in dB between sound pressure level of test subject and sound pressure level to correspond hearing threshold and to determine of formula:

\[
U_s = 20 \log \frac{p}{p_n}
\]

were:

\( p \) - sound pressure level in the frequency response hearing threshold of test subject,
\( p_n \) – sound pressure level in the frequency response normal hearing threshold,

In relative system, audiogram show open polygon connected points to determine hearing loss in the separate chose frequencies specific in dB HL that is threshold values of sound pressure to reference to normal hearing threshold in each from those frequencies and show in logarithmic scale.
3. Measuring results

The sample population consisted of 176 patients (47 women and 129 men) aged 20 to 30. The study was conducted hearing thresholds in the low (125 Hz - 8000 Hz) and high frequency (10 kHz - 16 kHz)\(^\text{12}\).

For all subjects had evidence of a previous damaging exposure, ie the selective loss occurring most frequently at a frequency of 6 kHz (rarely at a frequency of 4 kHz or 8 kHz). Sometimes the hearing loss frequency band included two of these frequencies.

The mean thresholds for right and left ear of subjects in the low frequency are presented in Figure 1. The mean thresholds for right and left ear of subjects in the high frequency are shown in Fig. 2.

**Figure 1.** Average values of the thresholds of hearing (dB HL) for the tested population in the low frequency range. Means and standard deviations of 176 audiograms; right ears and left ears.

**Figure 2.** Average values of the thresholds of hearing (dB HL) for the tested population in the high frequency range. Means and standard deviations of 41 audiograms; right ears and left ears.

The mean thresholds for right and left ear of subjects in the low frequency according to hearing loss with different depth are shown in Fig 3-6.
Figure 3. Average values of the thresholds of hearing (dB HL) for the tested population. Means and standard deviations of 21 audiograms; right ears and left ears.

Figure 4. Average values of the thresholds of hearing (dB HL) for the tested population. Means and standard deviations of 107 audiograms; right ears and left ears.

Figure 5. Average values of the thresholds of hearing (dB HL) for the tested population. Means and standard deviations of 40 audiograms; right ears and left ears.
Figure 6. Average values of the thresholds of hearing (dB HL) for the tested population.
Means and standard deviations of 8 audiograms; right ears and left ears.

In the low frequency was unilateral or bilateral of selective hearing loss with depth:
- 10 dB for 21 people (for 9 women and 12 men),
- 10-20 dB for 107 people (for 20 women and 87 men) ie. 70% of subjects,
- 20-30 dB for 40 people (for 18 women and 22 men) ie. 23% of subjects.

For 8 men, traces of exposure with depth over 30 dB, and were correlated with hearing loss appeared in the low and middle frequencies or in the all band of measure frequencies.

Mean thresholds for right and left ear of subjects in the high frequency according to hearing loss with different depth are given in Fig. 7 – 9.

Figure 7. Average values of the thresholds of hearing (dB HL) for the tested population.
Means and standard deviations of 8 audiograms; right ears and left ears.

Measuring of hearing threshold was carrying out in the high frequency range (10 kHz – 16 kHz) for 41 people (7 women and 34 men). In the high frequency was unilateral or bilateral of selective hearing loss with depth:
- 15 dB for 8 people (for 1 women and 7 men) ie. 19% of subjects,
- 20-30 dB for 15 people (for 1 women and 14 men) ie. 37% of subjects.

For 17 subjects was trace earlier damaging exposure with depth over 35 dB, mainly in the frequency band with the center frequency of 16 kHz.
The results show that 70% of all subjects in the low frequency range have small hearing loss (up to 20 dB) and 30% of all listeners have small hearing loss in the high frequency range. 23% of all subjects in the low frequency have the average hearing loss (from 20 dB to 30 dB) range and 37% of all listeners have average hearing loss in the high frequency range. 4.5% of all subjects (for 176 people) in the low frequency have big hearing loss (over 30 dB) range and 41% of all listeners (for 41 people) have big hearing loss in the high frequency range.

All results of hearing threshold it is possible to move in the frequency band with a center frequency of 250 Hz. This result was due to the resonance of the TDH 39P headphones and Peltor ear-piece system.

4. Summary

Voluntary participation in the carried diagnostic tests could influence the excessive representation people with hearing problems. It is why obtained results could be not representative for all population.

The obtained results of hearing loss over 10 dB are found in 88% of students in the low and high frequency ranges. The hearing losses with difference depth in the high frequency were found mainly in the 16 kHz. Survey results show that big hearing losses are caused by the exposure to high sound pressure levels of music as well as experienced illnesses. The persons with hearing loss 10 dB in the low frequency range and with hearing loss 20 dB in the high frequency range will be chosen for the next research experiments of ultrasonic noise influence on human body.
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