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INVESTIGATION OF NOISE THREATS AND THEIR IMPACT ON HEARING IN SELECTED SCHOOLS – A PILOT STUDY

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Noise measurements conducted in selected schools in Gdańsk area are presented in this paper. The main aim of this research was to determine noise threats at schools. Some objective measurements of the acoustic climate were performed employing a noise monitoring station engineered at the Multimedia System Department, Gdańsk University of Technology. Simultaneously, subjective noise annoyance examinations were carried out among pupils in chosen schools. The survey includes a noise analysis in places of residence, music preferences and preliminary hearing tests results taken after the exposure to noise during breaks. Hearing tests employing a distortion product otoacoustic emission (DPOAE) method, have been performed twice – before and after the exposure to noise. The noise dose analysis based on average time spent by a pupil at school is also presented. The obtained results reveal that an unfavorable noise climate occurred in surveyed schools. This was also confirmed by the results of the subjective examinations. The conducted hearing tests did not reveal essential changes in the cochlea activity of examined pupils. This means that the noise during breaks and physical exercises did not constitute a risk to their hearing system. However, it may be considered as an essential source of annoyance.

Key words: noise measurement, hearing, noise at school.

1. Introduction

Numerous research studies indicate that noise at schools is a serious threat both for pupils and teachers [4, 7, 12, 13, 15]. The pilot study presented in this article also took into consideration the acoustic conditions in classrooms [11, 12, 15]. The presented noise and hearing measurements are the continuation of the earlier screening hearing tests carried out by means of the “I can hear” system in numerous schools around the whole country [16]. The obtained results revealed frequent occurrence of various hearing problems among pupils. For this reason, it was decided that information about the acoustic climate in some selected schools should be gathered. Noise measurements were performed by means of an automatic noise measurement station designed in the Multimedia System Department, Gdańsk University of Technology [2]. At the same time, hearing examinations for selected persons were performed employing the otoacoustic emission method.

2. Noise and hearing measurements

The results of noise measurement, obtained by means of the Multimedia Noise Monitoring System (MNMS), are presented below. The measurements were performed in selected schools. The outdoor noise were neglected (schools were located in quiet places). The data gathered were utilized to perform the noise dose analysis. This was done to determine the noise exposure in considered places. In designated cases (i.e. in schools) the noise dose analysis was expanded by the assessment of hearing. To achieve this, the distortion product otoacoustic emission (DPOAE) method was applied. The hearing was examined twice. First, directly before the exposure to a given type of noise, and then immediately after the exposure. The performed analysis combined the obtained noise and hearing measurement results.

The following noise parameters $L_{\mathrm{AF\,min}}$, L_{Aeq}, $L_{\mathrm{AF\,max}}$ were measured independently over broadband and in one-third octave bands ($L_{\mathrm{AF\,min}}$, $L_{\mathrm{AF\,max}}$ – the lowest and highest A-weighted sound levels for fast time weighting, that occurred during the measurement, and L_{Aeq} – the A-weighted equivalent continuous noise level over a specified period of time that represents the same energy as the actual time varying noise signal [13]). A cumulative distribution for time history values of L_{AF} instantaneous levels was also calculated. A measuring microphone was located 1.9 m above the floor level for every measurement. For all measuring series, a place where pupils gather most often was selected in order to determine correctly a real noise dose to which they are exposed.

Hearing examinations employed the DPOAE method using GSI 60 DPOAE system. The following parameters of the stimuli were used during tests: L_1 equals 65 dB, L_2 equals 55 dB, $f_2/f_1 = 1.2$, DP frequency (geometric mean): 1062, 1312, 1562, 1812, 2187, 2625, 3062, 3687, 4375, 5187, 6187, 7375 Hz. A DP signal level and a noise floor for every stimuli were registered. The test result was accepted if the difference between evoked otoacoustic emission signals and the noise floor was not less than 10 dB. The reason of such selection of parameters was because the noise impact on the hearing system is the strongest for middle and high frequencies. The test was carried out in rooms specially adapted for this purpose. Some measurements performed in schools were interfered with sounds coming from adjoining rooms.

For the DPOAE hearing measurements a single measurement unit was used. For that reason only a few pupils could have been examined during a single measurement series which included the measurement of hearing before and after the exposure to noise. This means that the assessment was done only for one pupil directly before the exposure to noise. The hearing examination for all other pupils was delayed with respect to the beginning/end of the exposure to noise. This could possibly influence the change of activity in the cochlea for these people. Therefore, the effect evoked by the exposure could decrease directly before the examination. Taking these facts into consideration, we may assume that only a small group of pupils could have been successfully examined.

In addition, an objective noise measurement was extended by a subjective measurement by means of a dedicated survey. The survey consisted of three parts. The first part involved getting information such as age, sex, class, school. The second part included questions about noise in places of residence and exposure to noise related to musical preferences. The last part concentrated on noise climates in schools in typical circumstances (lessons, breaks, etc.).

3. Analysis of noise measurement results

The results of measurements for particular schools are presented in Table 1. This table includes all measurements taken in every school in any one of the measurement series. In addition, for every measurement series the cumulative distribution and one/third spectrum were also calculated. The equivalent level was used to determine the noise dose that occurred during breaks [1] (Noise Dose 1). Moreover, the noise dose analysis was extended by a daily noise dose estimation. Time of the exposure to noise corresponds to duration of breaks of a typical learning day (Noise Dose 2).

Table 1. Measurement results obtained for particular schools. Noise levels were expressed in dBA (reference level: $2 \cdot 10^{-5}$ [Pa]).

No.	$L_{\mathrm{AF\,min}}$	L_{Aeq}	$L_{\mathrm{AF\,max}}$	Time [s]	Noise Dose 1 [%]	Time total [s]	Noise Dose 2 [%]
School No. 1							
1	64.5	86.9	102.1	600	**3.2**	3000	**16.2**
2	67.4	89	105.5	600	**5.2**	3000	**26.2**
3	74.5	86.1	111.3	1200	**5.4**	3000	**13.4**
School No. 2							
4	67.2	85.5	106.8	900	**3.5**	3600	**14.0**
5	69.5	84.3	103.1	900	**2.7**	3600	**10.6**
School No. 3							
6	56.5	79.1	93.4	600	**0.5**	3600	**3.2**
7	72	83.6	97.4	600	**1.5**	3600	**9.0**

Taking equivalent levels into consideration, it was affirmed that the highest noise level occurred at school No. 1 (the highest L_{Aeq} was equal to 89 dBA!). This was related to pupils' behavior. They behave extremely vigorously, and were the main source of noise during breaks. It is worth emphasizing that pupils from school No. 1 were the youngest from all of those examined. In school No. 2, children were between the ages of

13 and 15. Youth aged from 16 to 19 attended school No. 3. The age of pupils explains their behavior during breaks. In school No. 2, noise levels were slightly less obtrusive (L_{Aeq} about 85 dBA). In this school, additional source of noise was loud music played from the loudspeakers. Long corridors without any sound absorbing materials were also the factor that heightened noise level. The lowest noise levels were identified in school No. 3 (83.6 dBA). For school No. 1, a more dynamic range of noise levels was obtained, which was also reflected in the shape and width of the cumulative distribution curve (see Fig. 1). Cumulative distributions obtained for schools No. 2 and 3 showed essential similarity. High and steep slopes indicated that noise levels concentrated near one constant sound level. This reflects the character of the main noise source. As mentioned before, this was the loudspeaker system in school No. 2, for example. In school No. 3, the noise was produced by loud conversations.

The noise spectra were fairly similar for all schools in general. The significant difference occurred for low and middle frequencies. For elementary schools No. 1 and 2, high levels were identified for frequencies lower than 100 Hz. This was certainly related to pupils' vigorous behavior characteristic for their age. As mentioned before, pupils from school No. 3 were adolescents thus they behaved more calmly. The greatest noise levels in the range between 630 and 2500 Hz were observed in school No. 1.

However, the analysis it was affirmed that the noise dose during a single break is insignificant from the statistical point of view. The noise dose amounts to 5% for school No. 1, approximately 3% for school No. 2 and 1% for school No. 3. These values are obviously greater for a total daily exposure – the biggest for school No. 1 (26%) and to some extent lower for schools No. 2 and 3.

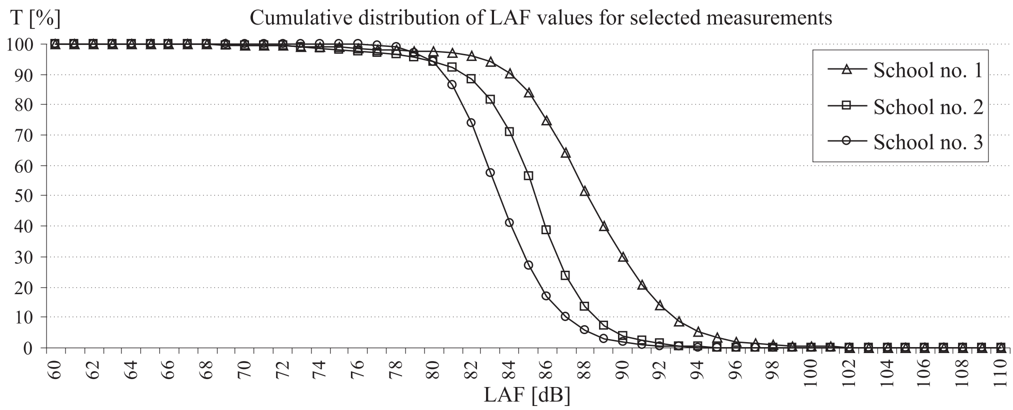

Fig. 1. Cumulative distributions for particular schools (for selected measurements).

3.1. Hearing measurement results

Twenty persons overall took part in hearing tests. Ten of them were examined in school No. 1, five in school No. 2, and the remaining in school No. 3. Two different aspects were taken into consideration while analyzing the results. First, the number of "passed" and "failed" tests for the second examination were determined. The result of the first examination served as reference. The symbol "+Pass" indicates that a pupil failed the first examination and passed the second one. The symbol – "Pass" signifies a reverse situation (a test passed in the first examination and failed after the exposure to noise). The results are presented in Table 2, in the "DPOAE test results" column. The second kind of analysis determined how the DP signal level changed under the influence of the exposure to noise. The results of this analysis are presented in Table 2, in "The average changes of DP signal level" column.

Table 2. Hearing testing results using DPOAE method (in %).

School	DPOAE test results			The average changes of DP signal level		
	+ Pass	− Not Pass	No change	Increase	Decrease	No change
No. 1	11.0	13.6	75.4	30.3	28.1	41.6
No. 2	10.0	19.2	70.8	27.5	30.0	42.5
No. 3	3.3	12.5	84.2	36.7	34.2	29.1

The cochlea activity characteristics that were obtained by means of the DPOAE method do not clearly confirm that the noise occurring during breaks has negative impact on the hearing of examined persons. The average changes of the DP signal level for examined persons substantiated in this situation. Differences between the increase and decrease of the DP level induced by the exposure to noise measured for every group of pupils, were insignificant regardless of the type of school. Differences for the DP levels characteristics were within the range of measurement error which may be produced by a different location of the measurement sensor in the ear canal. It is important to emphasize that to obtain reliable results with the DPOAE method, a very silent room is required. From all considered cases, the best measurement conditions were in school No. 1. The measurements in school No. 2 and 3 were done in the headmasters' offices. In these circumstances some measurements were disturbed by sounds from adjoining rooms. However, the measurements were repeated in such situations.

3.2. Survey result analysis

Evaluation of noise at place of residence

On the basis of the answers related to noise at place of residence, it was found that the questioned people's environment is loud during the day and quiet in the night. The most often indicated source of noise in the place of residence was a roadway noise (38.6%). The neighborhood noise (34.1%) was a second one.

Evaluation of noise at school

The noise measurement results are consistent with the survey results for the noise during breaks. More than 62% persons questioned in all types of schools estimated the noise at breaks as very loud while almost 30% of the remaining pupils said that it was loud. The presence of loudspeaker systems is typical in schools for older children and youths. Such an installation can constitute an essential source of noise. Noise during lessons was in most cases assessed as low or moderate.

Noise during lessons was the largest problem with the youngest pupils from school No. 1. This concerned speech intelligibility. More than half of the questioned pupils from this school judged the noise as loud or very loud. Pupils also noticed that noise should be reduced especially during breaks (more than 60% answers). Some of them mentioned the noise problem in classrooms during lessons (about 20%). Merely 14% of the questioned persons pointed out that noise should be diminished during physical activities. Approximately 10% of the pupils did not notice the noise problem at school at all.

Evaluation of noise concerning music and entertainment preferences

The analysis of preferences on music and entertainment of pupils from different groups of age provided very interesting information. As many as 60% questioned pupils from school No. 3 (youth) listen to music at loud or very loud levels, 30% preferred moderate levels. However, 60% of questioned pupils from school No. 2 and 1 pointed out that they listen to music at moderate or low levels. This data show, how the preferences change with age. This could be an essential factor in the loss of hearing inducted by noise amongst adolescents. Using headphones for a long time is the next cause of the hearing impairment risk. Older pupils more often used such kind of equipment. This can constitute an essential hearing threat for persons which use them frequently and for a long time [14]. Nowadays, there is a very large offer of portable music players on the market and teenagers willingly use them. Pupils were also asked how much time they spend listening to music. Their answers confirm the intuitive presumption that duration of a single session of listening to music grows with age. Listening to music is very popular among the youths. The next type of noise hazard is participation in loud parties and musical events [5–10]. Also in this case, the percentage of youngsters who prefer such type of free time activities grows with age.

4. Summary and Conclusions

The pilot study performed shows that the noise climate in the considered schools is adverse. The main reasons of the high level of noise in schools are pupils' behavior and the lack of sufficient absorption of walls in classes and corridors. In some cases loudspeaker systems constitute another essential factor of the increase in total noise level. Taking this into consideration, it is necessary to emphasize that noise in schools can be a key source of tiredness and stress, not only for pupils but also for teachers. On the other hand, for older pupils, listening to music and participation in loud sound events constitute a high risk of developing a hearing loss. Based on the criteria of risk of hearing loss induced by noise [7], it was affirmed that for elementary schools the noise level during breaks may contribute to real hearing damage risks. For other types of schools the risk is between mid and high. The data analysis of hearing measurements at schools does not confirm the negative influence of noise on hearing, as yet. This is because the time of the exposure to noise was too short to produce measurable changes in the activity of the inner ear.

The results from the survey showed that pupils are exposed to annoying noise not only in their place of residence but also in their schools. The type of school, behavior of pupils, installation of loudspeakers, noise absorbing materials, etc., all form acoustical climate. Also, it was observed that older pupils have greater tolerance for excessive noise in their environment. Younger pupils tend to avoid loud sounds. As they grow up, they put themselves at loud noise threats more voluntarily.

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