Influence of Noise on Children's Sense of Hearing

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Abstract

Children are at risk of developing hearing problems due to their exposure to high sound pressure levels for excessive amounts of time. The aim of this project was to establish the relationship between sound levels in the most hazardous fields and their effect on children's sense of hearing. Measuring sound pressure levels in schools, analysing earphone and headphone usage and comparing them to audiometry results enabled basic dependencies to be found. Some of the examined children fall outside the safe exposure times to certain sound pressure levels (according to WHO directives). The results analysed in frequency bands show that there is a clear correlation between a shift in hearing threshold and intensity levels in music. Noise during lessons is not very high, but the noise during breaks and of bell rings can influence children's' hearing to a certain extent. Due to improper usage of earphones and headphones, the young people we examined may develop hearing loss at an early age.

Keywords: hearing loss, acoustic reflex, school noise, headphones, earphones, music spectrum

1. Introduction

Hearing is one of the most important senses and it's health should be protected. The purpose of our study was to find out whether and to what extent the sound and noise that surround children every day affect their hearing. It is well known, that long-term exposure to loud sounds can negatively influence the sense of hearing. It is especially dangerous for children, because their body is still evolving, which makes them more vulnerable to hearing problems that could affect their entire future life. The sources of sound that are the most dangerous were divided into 3 groups: noise in schools, noise generated by public transport, and music listened to through earphones and head-phones.

The acoustic reflex is an important phenomenon these studies. The sound pressure level (SPL), that triggers the stapedius muscle contraction ranges from 70 to 90 dB SPL [1]. The purpose of this reflex is to protect our hearing organs from the high energy sounds , that could potentially have a negative impact on our hearing. When a sound coming to our ears is above the acoustic reflex threshold (ART), the stapedius muscle contracts, decreasing the energy that comes to the cochlea [2, 4]. The stapedius muscle is very small (6.3 mm) and is unable to work for a long time. It's role is to protect our hearing when a short, high energy level sound appears [3, 4].

When the sound level is above the ART and it lasts longer than a few dozen seconds (depending on sound frequency), the muscles simply get "tired" and no longer help us deal with noise [1]. This is the reason why the SPL, which triggers the acoustic reflex has been chosen as a reference for the measurements.

The sounds and noise that surround children and which we have chosen for measurement are partially over ART, and certainly last longer than a few seconds. This means that children's hearing can be harmed. The children that took part in our studies spend from 28 to 31 hours a week at school in lessons and another 5 hours during breaks. On their way to and from school, they sometimes travel by public transport, which can also be noisy (but this depends on the vehicle), and while travelling they also use earphones and headphones. Taking these factors into consideration, exposure to high level sounds might have a serious effect on their hearing, and this constitutes the subject of our research.

2. The research group

The research was carried in two schools: the 66 Primary School and the 62 Primary School in Poznań, Poland. They are both district schools, which increases the probability that the children have neither serious hearing problems (which could be qualified as disabilities) nor extraordinarily responsive hearing (which could be possible in music schools or classes). 35 children aged 10-13, from two classes (5th and 6th grade) were examined. None of the participants has ever taken part in any similar project before. We assumed that the level of knowledge and experience concerning the subject of our research is similar in the group as a whole. Nobody reported hearing problems before participating in the project. There were representatives of both head-phone and earphone users among the participants. We treated 12 children that do not use headphones or earphones as a control group.

3. Methodology and equipment

To specify the noise sources that affect children's hearing to the greatest extent, three main sources of noise and sound were chosen: schools, public transport and earphones/headphones.

In schools there were three areas to be explored: the noise of bell rings, noise during lessons, and noise during breaks. All these types were analysed in relation to exposure time. When it comes to listening to music, WHO directives might be exceeded, in terms of both loudness and listening time. The SPL in different means of public transport were measured. The influence of this high background SPL on higher music volumes was also investigated.

The first field of research was primary schools (SP). We measured the acoustic background in empty classes and corridors when children were absent. We measured sound levels using SVAN945 and SVAN945A sound level meters. The second part of our study involved measuring sound levels during classes and breaks. We measured the equivalent sound pressure level during lessons (45 minutes) and during breaks (10 minutes). We used the same meters as previously.

The next part of the project was to check the volume at which children listen to music. In order to do this, we used mp4 players (Lenco Xemio-668), in-canal earphones (Pioneer SE-C1T(R)) and over-ear headphones (Motorola Pulse Max). There were music files saved on the devices (Brotherswing by Caravan Palace). Mp4 players were chosen because it is an easy volume adjusting system. There were discontinuous values from 0 to 27 assigned to the actual loudness. The children participating in the project were divided into 3 groups – the ones that use earphones, the ones that uses headphones and the ones not using either. During tram journey, children were given an mp4 player, played a the song and adjusted the music volume as they felt comfortable. The settings - the volume level - for each child were written down. After each listening session we changed the earphone buds and cleaned the headphones, for hygienic purposes. The measurements were made on Poznan's Fast Tram (Poznański Szybki Tramwaj - PST). We chose public transport as a place to take sound volume measurements because most of the children use headphones while traveling.

The third field of the research concerns children's hearing health. A pure tone audiometry test was performed for each child.

The forth part of the research involved measuring how the mp4 settings correspond to the pressure level in dB. To check this, we took a Neumann KU 100 artificial head, and using Bruel & Kjaer Pulse LabShop, calculated how loud the sound on headphones and earphones really was.

The last part of the research involved establishing the sound pressure level of the noise in public transport. We travelled using different types of trams and routes, and buses as well. We measured the equivalent sound pressure level (L_{AeqT}) using SVAN945 and SVAN945A sound level meters.

Finally, we took all of our data and copied them into MS Excel. We also used SvanPC and SvanPC++ to read results from the sound level meters and MATLAB to perform some calculations.

4. Results and discussion

4.1. *Schools*

The sound levels measured in schools are featured in Tables 1 and 2.

Table 1. Background noise level in SP 62

Class	Background noise level [dB A]
Computer lab	41.3
Chemistry lab	23.4
Classroom on the ground level	31.2
Classroom on the first floor	31.0
Classroom on the first floor close to a street (lights turned off)	40.3
Classroom on the first floor close to a street (lights turned on)	28.4

Table 2. Background noise level in SP 66

Class	Background noise level [dB A]
Class on ground level (lights turned on)	37.2
Class on the first floor (lights turned on)	35.5
Class on the second floor (lights turned on)	36.3
Class on ground level (lights turned off)	25.6
Class on the first floor (lights turned off)	24.5
Class on the second floor (lights turned off)	29.2

Table 3. L_{AeqT} during classes and breaks

School	Class	L_{AeqT} [dB A]
SP 62	Mathematics	64.8
SP 62	Biology	64.2
SP 62	Break	88.9
SP 66	Mathematics	61.4
SP 66	Substitution	75.4
SP 66	Break	97.3

Table 4. L_{AeqT} during breakes when the bell rang

School	L_{AeqT} [dB A]
SP 66	98.3
SP 66	100.1

The first conclusion concerns schools and the noise inside them. We are positively surprised, that the background noise is low - usually under 35 dBA. The exceptions are only the computing class, which is probably caused by the fans inside and classes with old, halogen light bulbs – their sound pressure level is high enough to cause an audible difference [Tables 1, 2]. Another conclusion is that L_{AeqT} during classes is not as high as we had expected – it is lower than the acoustic reflex threshold, so lessons are not hazardous for children's hearing. The only exception was substitutions, but these are a minor part in the weekly teaching schedule, so they should not affect hearing [Table 3]. Unfortunately, breaks and bell rings in schools are dangerous. With sound pressure levels over the acoustic reflex threshold, they can cause serious problems and lead to hearing loss in the future [Table 4]. Children spend approximately 5 hours a week on breaks, which is longer than WHO describes as safe. Unfortunately, due to the limitations of our small research group we can not be sure how it actually affects children, but the average absolute hearing threshold (AHT) is higher than we would expect, considering the age of the children was 10-12. This may be caused by school or public transport noise, but there may also be other threats we did not take under consideration.

4.2. *Public transport*

To find out how noisy it actually is inside trams and buses, we measured the equivalent sound pressure level using an SVAN 945A sound level meter. We travelled by old and new trams on the PST route and by the 168 and 198 buses, both articulated and ordinary ones. We collected data from 5 minute periods [Table 5].

Table 5. L_{AeqT} in trams and buses

Model	Line	L_{AeqT} [dB A]
Konstal 105Na	14	83.9
Solaris Tramino S105p	12	79.0
Solaris Tramino S105p	15	77.5
Solaris Urbino 18	198	76.7
Solaris Alpino	168	69.5

4.3. *Type of headphones*

We examined how the type of headphones used affects hearing. To do so, we measured sound pressure level using artificial head in ear canals with in-canal earphones and under over-ear headphones. Then we compared those values and searched for a correlation between type of headphones and absolute hearing threshold.

Table 6. The relation between the loudness on mp4 players and L_{pA} on headphones

Volume	L_{pA} [dB A]
10	63.8
12	70.2
15	74.5
16	77.7
20	85.0
22	88.6
24	91.5
27	98.7

Table 7. The relation between the loudness on mp4 players and L_{pA} on earphones

Volume	L_{pA} [dB A]
8	72.3
12	81.1
13	84.4
15	86.0
17	90.2
18	93.2
19	93.9
21	100.3
27	108.0

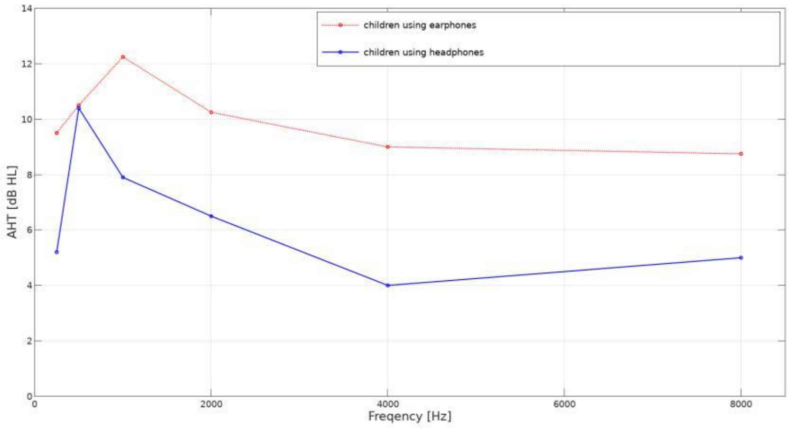

Figure 1. Comparison between headphones and earphones influence

The conclusion is clear - we can see that children that use in-canal earphones have slightly, but significantly higher AHT than children using headphones. As it turns out, L_{pA} in earphones is much higher then in the headphones, when we set the mp4 loudness to the same volume level, and this may cause a difference in absolute hearing thresholds [Table 6 and 7] [Figure 1].

4.4. *Connections between noise and hearing*

In our study we wanted to know if and how listening to music using earphones and headphones can affect childern's hearing. To do so, we performed pure tone audiometry and then we were looking for correlations.

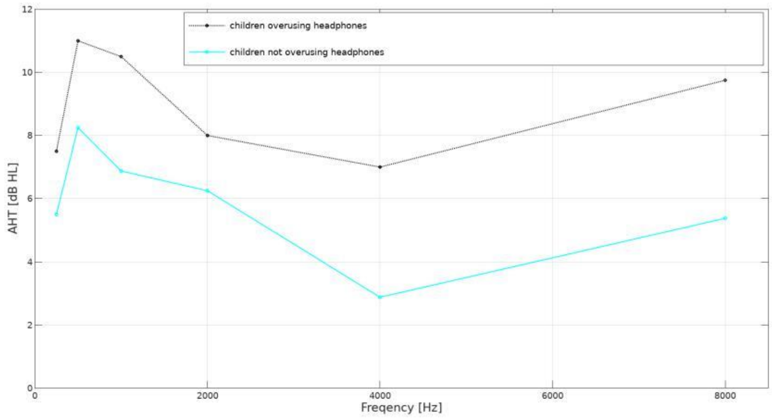

Figure 2. Thresholds

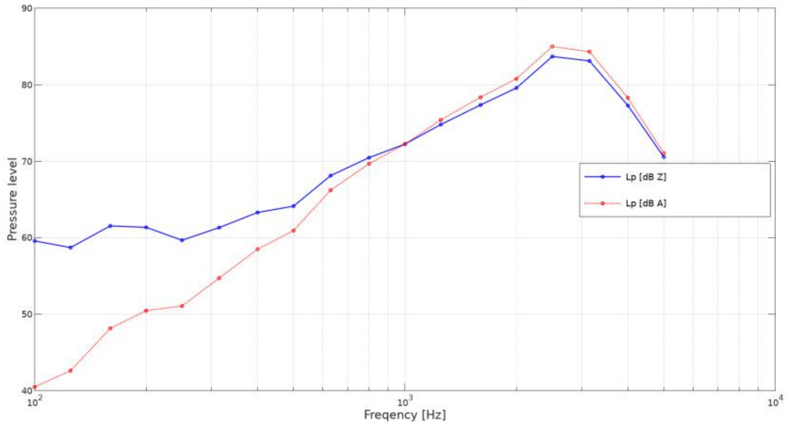

Figure 3. Music spectrum

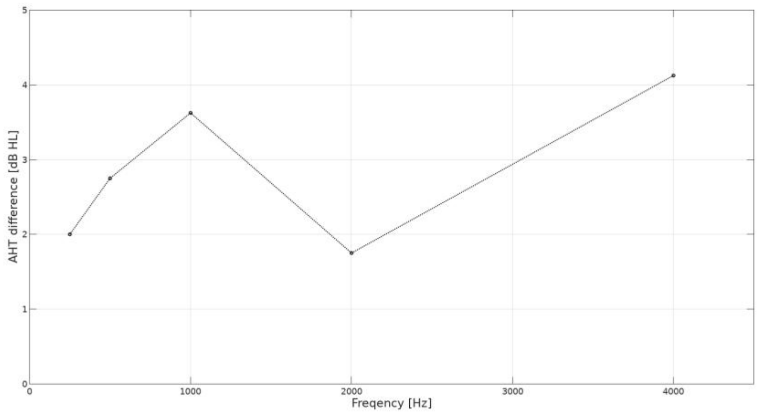

Figure 4. Difference in Absolute Hearing Thresholds

The last conclusion is the influence of earphone and headphone usage. As we can see in Figure 2, children that use earphones and headphones for longer periods or at louder settings (we will say that they overuse headphones) than WHO recommends have a higher absolute hearing threshold. We can see a correlation between a shift of AHT and the music spectrum - with the exception of 2000 Hz [Figure 3 and 4]. It is difficult to tell why this is so. The biggest difference is at around 4000 Hz, where the maximum of music energy is – and although our results might be uncertain, due to the small research group and the difficulties associated with pure tone audiometry, they are backed by theory. It is very worrying that the AHT of such young people is so high. If nothing changes, these children might become hearing-impaired in a few dozen years just because of extensive and improper usage of headphones and earphones.

5. Conclusions

The research group was large enough to show basic dependencies, although to gain a better understanding and perform a more thorough examination the group should be bigger. The schools investigated are district schools located in rather quiet surroundings. The outcomes may differ if the circumstances change - for example, if the schools are situated near a loud road, airport or level crossing, it would negatively affect background noise level. The number of children in classes may also play a role in the sound pressure level during lessons and breaks. Public transport can also be very loud, but due to the modernization of trains and buses this problem might be eliminated in a few years, because newer vehicles are quieter. We have only analysed 5 pieces of music of different genres. To get a more precise relationship between music and the absolute hearing threshold, more genres of music should be examined.

We believe that thanks to our study and the workshops that we conducted for children, they will be more aware of possible threats to their hearing. What is more, the schools where we have conducted our research receive feedback from us, so that they can improve the acoustic conditions in schools and make learning more effective and the time spent during breaks safer.

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