Tendencies in the Worsening of Hearing Thresholds of Pupils with Regard to Leisure Noise

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1. Introduction: Basic Problems

There has been considerable literature over the last 10…20 years ascertaining a worsening of the hearing capability of young persons. Especially the papers by BORCHGREVINK ([1], 1988 and 1993) caused a sensation. He stated that the share of 18 years old men with hearing loss of 20 dB at one frequency increased from 17% (1981) to 35% (1987) in Norway. Further investigations by himself and by other authors in different countries confirmed this tendency (but fortunately not the amount) and supposed leisure noise to be the major reason (cf. [2] – [7]).

Problems of noise-induced hearing loss are well known from investigations on occupational noise exposure which resulted in the fixing of different limits. In Germany there are e.g. limits of the equivalent continuous sound level L_{eq} = 85 / 90 dB(A). According to ISO 1999 a noise exposure of L_{eq} = 90 dB(A) during 40 h per week causes a hearing loss of at least 11 dB at 4 kHz with a probability of 50% within 10 years. This noise exposure is e.g. equivalent to 102 dB(A) within 2,5h/week corresponding to one attendance of a discotheque per week, see below (cf. [8], [9]).

Taking into account the situation of young people it would be of special interest to identify the beginning hearing loss prior to progression into the conventional auditory area 125Hz...8kHz (speech-frequency range). Former investigations yield indications that the high frequency auditory area (8kHz...20kHz) is particularly sensitive and thereby may give the opportunity for an early detection of a possible hearing loss caused by ototoxic agents, presbyacusis, middle-ear diseases, noise exposure (see [10], [11]).

2. Noise exposure and hearing thresholds

2.1. Longitudinal study: Measurement methodology

A longitudinal study was performed to investigate the change of personal hearing thresholds of school-aged children within 3-4 years. The chance for this was given by a cooperation in the field of „Noise and hearing“ with a lower-grade secondary school in Mittweida, which has the subject „Environmental and ecological Problems“ on the curriculum. 1997–2003 annual tests of pupils of 7.–10. class were performed (330 audiograms) and about 1000 questionnaires were evaluated. Analysing the data a comparison of 6 samples with same pupils at different classes (classes 7.-8., 8.-9., 9.-10., 7.-9., 8.-10., 7.-10) was made. Every sample contains measurements within 4-6 years with 50-75 audiograms. The aim was to look for answers of the following questions: a) Is there a characteristic age of the beginning of a significant worsening of the hearing? b) Is it possible to detect any correlations between leisure noise exposure and worsening of hearing and are there special patterns?

The measurements were performed with a high-frequency audiometer (type Hortmann Ca 540/1) in a special sound-insulated room and with a tympanometer (type Tymp 87). Persons with striking tympanometric findings were excluded from statistics, since this is a hint at a hearing impairment which is normally not noise induced.

2.2. Examples of personal noise exposure

a) Some of the results of the questionnaire:

75 – 80 % of the pupils of 7.-10. class are listening to music (radio) “often – very often” and 54 – 68 % (slightly increasing with age) report to do this “loud – very loud” (in both cases rank 4 and 5 on a 5-degree-scale). The attendance of discotheques strongly increases between 9. and 10.class:

8./9. class > 5h/month : 25% >25h/month : 5%

10.class > 5h/month : 50% > 25h/month : 25%

79 – 91 % of the pupils (decreasing with age) posses a “Walkman”, but the number of “extensive users” (>15 hours/week) decreases with age: 7.class : 16% ; 8./9.class : 10% ; 10.class : 3% .

b) The results of dosemeter measurements of different types of leisure noise exposure are shown in table 1 at the end of the paper. Particularly high sound pressure levels and noise exposures can be detected in discotheques and at rock-concerts, but also at indoor-sports with many spectators. The noise exposure of one event may come up to that of 70 working-days at the limit of L_{eq} = 85 dB(A).

2.3. Audiometric testing

2.3.1. Average of the hearing thresholds

Nearly all samples show a worsening of the hearing threshold averages (see tab. 2). The share of test-frequencies with significant worsening is approximately 50%. The highest hearing loss is found in the high-frequency range (averages up to 3,4 dB) and 16 kHz is the most frequently affected test-frequency. Two examples of worsening of average hearing threshold together with it’s confidence interval (level of significance 95%) are shown in fig.1.

Table 2 : Worsening of the average hearing threshold (level of significance: 95%; total number of frequencies :17)

sample	7.-8.	8.-9.	9.-10.	7.-9.	8.-10.	7.-10.
Number of freq. with worsening	10	0	6	3	9	6
Frequencies with worsening (kHz)	0,25...3, 9 ...10 16		1...1,5 3; 4; 9;16	1 ... 2	0,75 ... ...6, 14 ... 16	1 ... 3, 14 ... 16
aver. worsen. (dB)	1,7	-0,6	1,3	0,4	2,1	2,3
9,0...16,0 kHz (dB)	1,9	-0,5	1,5	0,4	2,7	3,4

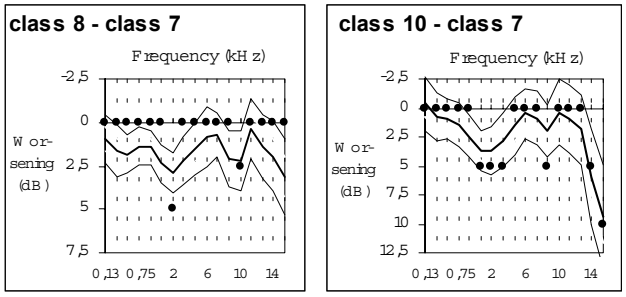
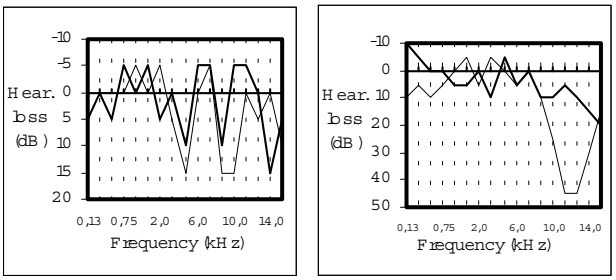


Figure 1: Examples of worsening of hearing threshold (solid lines: average worsening; thin line: confidence interval; dots: median)

2.3.2. Patterns of hearing threshold changes

A comparison of the frequency of the c5-dip (preferably noise induced) with loss in the high-frequency range (at least 10 dB) yields the following results: i) Losses in the high-frequency range occur more often than dips at 4-8 kHz. ii) Losses in the high-frequency range occur more often without a dip at 4-8 kHz than together with a dip (fig. 2, right fig.). iii) Dips at 4-8 kHz occur more often together with loss in the high-frequency range than without it (fig. 2, left fig.). These findings give some indications for a higher probability of an early change in hearing sensitivity in the high frequencies prior to progression into the conventional auditory area.



a) Dip at 4-8 kHz, one or two dips in the high-frequency range

b) Dip or general loss in the high-frequency range, no dip at 4-8 kHz

Figure 2: Patterns of hearing threshold changes

2.3.3. Analysis of subgroups

In order to investigate correlations between hearing loss and noise exposure two subgroups were formed in any sample:
A) Persons with a distinct worsening of the hearing thresholds (at least 1 x 20 dB and/or 2 x 15 dB),
B) Persons with strong worsening of the hearing thresholds (at least 1 x 30 dB and/or 5 x 15 dB).
Subsample A occurs with a frequency of 20-28% in the total samples, subsample B with a frequency of 4-16 % , increasing with increasing age. The combination of hearing loss "dip at 4-8 kHz + high frequency loss" exists on average by a factor of 1,7 more often in A than in the total samples. Furthermore, some hints at correlations between hearing loss and leisure noise exposure could be found :
- In subsample A the frequency of the answers "listening to music loud-very loud" and "attending a discotheque often-very often" is by factors of 1,20 and 1,11 higher than in the total sample.
- The combination "listening to music loud-very loud" and "listening to music often-very often" occurs in subsample B by a factor of 1,24 more frequently than in subsample A.
Consequently, pupils which are stronger exposed by loud music show a higher probability for a hearing loss.

3. Summary

Because of the high sound levels and the frequent attendance discotheques causes a particularly high hearing damage risk. For a small part of the school-aged children other types of individual perception of music (Walk- / or Discman, car-radio) or additive effects of different types might be important. Confirming the results of a former study [12] a strong increase of the worsening of hearing thresholds occurs especially at an age of about 16 years. The increasing frequency of the attendance of discotheques beginning with an age of 13 years could be one reason for that.
High-frequency hearing is especially sensitive for noise exposure. Probably there exists a correlation between hearing impairment in the high-frequency range (> 8 kHz) and in the conventional range (< 8 kHz).

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Table 1: Noise exposure of the attendance (dosemeter measurements)

Typ	Event	Duration	Numb.	L_{eq} (dB(A))		L_{AFmax}	E (Pa^2h)	
				Aver.	Variance	dB(A)	Aver.	Variance
Music	Commercial disco	2 ... 5 h	14	100	95 ...104	113 ... 137	10,6	6,5 ... 47
	Rock - concert	1,6 ... 3 h	5	105	100...111	118 ... 130	36	26 ... 72
	Walkman: pupils 9./10.class; stud.	1-3 pieces	35	80	61 ... 93			
Sports	Soccer (2./3. league)	105 min	54	90	75 ... 104	95 ... 137	3,5	0,01 ... 22,5
Indoor sports	Soccer	4 ... 4,5 h	3	102	98 ... 106	131 ... 136	34	12 ... 69
	Handball (3.league)	100 min	3	92	90 ... 94	109 ... 122	1,0	0,6 ... 1,7
	Basketball (2./3.league)	1,3...2,1 h	21	104	97 ... 110	105 ... 137	19	1,8 ... 75,4
	Icehockey	2,5 h	2	97	95; 98	115; 130	4,9	2,7 ; 7,1
Others	Kart - race (indoor): spectator	ca.60min	2	90	90 ... 91	-	0,455	0,4...0,5
	driver	2X10min	1	101	-	-	1,7	-
	Computer games	1 ... 2 h	9	68	65...71	80...117	0,004	< 0,01
	Car driving with radio (students)	0,2... 2,0 h	27	81	67 ... 106	84 ... 126	0,2	0,01 ... 2,3