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Tinnitus, noise and health effects in preschool environments

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The study included 93 employees at 17 preschools in the county of Umeå located in northern part of Sweden. Personal daily noise dosimeter recordings were made at five representative work days. Stationary noise recordings were made during the same days at two departments of each preschool, in the playing halls and in the dining rooms. Besides audiometric tests, the employees rated their experiences of the noise, hearing and tinnitus as well as well as different health effects, on validated questionnaires. Tinnitus was reported among 31 per cent of the participants. The study group was dichotomized into employees with or without tinnitus. Employees with tinnitus reported higher prevalence of subjective hearing loss, higher experiences of elevated sound levels at work, anxiety of the noise at work, chest pressure/pain, burn out symptoms, depression and reduced sleep quality. Significant differences were seen for shoulder tension/pain. No group differences were seen for the objective personal or stationary noise measures or the number of children present at the department. The results of the study are discussed in terms of underlying causes and the way in which the symptom interfere with experiences and health effects of the employees.

1 Introduction

Noise exposure in the preschool is characterized by several features that are harmful in the perspective of the pedagogic work that is carried out. Beside the relatively high daily noise level, the environment includes a number of sources making fluctuations a prominent characteristic of the exposure. In addition, the noise is dominated by voices with frequency and informational characteristics that makes the risk for hearing impairment, speech masking and annoyance highly pronounced. The characteristics of the noise exposure are in conflict with the demands of the work in several aspects, not at least the communication part of the education.

The consequences of long time noise exposure in preschool environments, characterized by high mental effort and other stressors, are far from clarified. The annoyance and the effects on speech and listening at the occurring noise levels, have been verified in several studies [1].It is a well-grounded assumption that this might be a critical part of noise interactions in the preschool environments.

The adverse effects of noise and noise level fluctuations have been described in a recent field study carried out [2]. The harmful interaction between demands on concentration and noise fluctuations, especially in cases of uncontrolled noise exposures are of special interest. Noise exposure not only increases the risk of developing a hearing loss. Other hearing impairments such as tinnitus also constitute effects of the exposures in preschools. Tinnitus prevalence in the general population is approximately 10-15% [3]. It has also been shown that tinnitus is more likely to be perceived by patients with hearing loss [4,5]. Tinnitus may also affect the sufferer with depression and anxiety [6].

The aim of this study was to analyze the noise exposure in the preschool departments, experiences and health effects with focus on tinnitus and its relation to exposure and adverse responses.

2 Methods

2.1 Employees

The study included 93 employees at 17 preschools in the county of Umeå located in northern part of Sweden.

2.2 Noise

Personal daily noise recordings (Bruel & Kjaer 4445 and Larson Davies 706-Atex) were made at five representative work days (Monday – Friday). Stationary noise recordings (Brüel & Kjaer 2260) were made during the same days at two departments of each preschool, in the playing halls and in the dining rooms. The noise exposures are described in terms of dB(A) and fluctuations of the noise levels. The noise fluctuation is measured as the number of one second periods where sound levels exceeded 85 dB(A).

2.3 Hearing

Audiometric tests were conducted in a quiet room at the preschools by a company healthcare nurse. The screening was conducted on both ears with either 0 dB or 10 dB sensitivity at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz and 8000 Hz, using earphones. The subjective experience of hearing impairment was assessed using a three item question ranging from no problems to strongly impaired.

Subjective hearing status was reported on a one to three scale (1 = no hearing problems, 2 = slightly hearing impaired, 3 = severely hearing impaired).

2.4 Tinnitus

Tinnitus was assessed using questions covering the prevalence of tinnitus and how the tinnitus was perceived (both ears, left ear, right ear, other experiences). Questions regarding when and how often tinnitus was perceived were asked as well as questions regarding discomfort.

2.5 Stress

To measure the subjective stress and its relation to the psychosocial work conditions, the Stress-Energy adjective check list was used [7]. This questionnaire contains twelve items measuring two factors, *Stress and Energy*. Each item is rated on a scale ranging from 0 (*not at all*) to six (*extremely*) [8-11]. The stress levels were measured at four time points (at wakeup time, one hour after wakeup, 11.00 am and 09.00 pm). In the present study the rated stress levels at 11.00 am (during work) was used.

2.6 Fatigue

Subjective fatigue was measured using the Swedish Occupational Fatigue Inventory (SOFI) [8,9], a questionnaire developed to measure fatigue in five dimensions. These five dimensions are lack of energy; physical exertion; physical discomfort; lack of motivation and sleepiness. Each factor is measured with five items rated from 0 (*not at all*) to 6 (to a *very high degree*). In this study the dimension “lack of energy” was used as a marker for fatigue.

2.7 Burnout

Burnout was measured using the *Shirom-Melamed Burnout Questionnaire* (SMBQ) [10,11]. The SMBQ contains of four subscales with a total of 22 items. Each item is rated on a seven point scale graded from 1 (almost never) to 7 (almost always). The subscales are: emotional and physical exhaustion; tension; listlessness and cognitive weariness. A higher score indicates higher level of burnout.

2.8 Effort-Reward

Stress inducing work characteristics were assessed with the *Effort/Reward Imbalance model* (ERI) [12]. The ERI model measures the effort and commitment that is put into work by the employees and to what extent this is rewarded in terms of material assets, feedback and appreciation and has been shown to predict stress related health problems [13]. The ERI model also provides information regarding the employee's thoughts of leadership and organization. A value higher than 1.0 indicates a severe imbalance between effort and reward, meaning that the employees do not feel rewarded for the work they put in.

2.9 Sleepiness and Sleep

The Karolinska Sleepiness Scale (KSS) was used to assess sleepiness[14]. The KSS is a 9-point scale with verbal anchors: 1= very alert, 3=alert, 5=neither alert nor sleepy, 7=sleepy, but with no difficulty staying awake and 9=very sleepy, fighting against sleep, requiring great effort to stay awake. The Karolinska Sleep Diary (KSD) was used to assess different aspects of sleep, including quality of sleep.

2.10 Chest pressure/pain and Shoulder tension/pain

Chest pressure/pain and shoulder tension/pain was evaluated using questions regarding prevalence during the last two months on a five point scale (1 = never, 2 = one to two times, 3 = three to four times, 4 =five to six times, 5 = more than six times).

2.11 Depression

Depression was assessed using the Major Depression Inventory (MDI) [15,16]. This is a commonly used self-reported questionnaire that can be scored by the total sum of the items to the WHO ICD-10 [17] algorithms for depressive symptomatology and the severity scales. The MDI items were rated on a scale ranging from a*ll the time* to *at no time*, using the last two weeks as a time frame.

2.12 Cortisol

In the middle of the study week (Wednesday), stress cortisol was collected four times using saliva sampling kits (Salivette®, Nümbrecht Germany). Time of leaving the samples were immediately after wake up, one hour after wake up, at 11:00 am and at 09:00 pm. Cortisol Awakening Response (CAR) and Cortisol Decline over the Day (CDD) were calculated. CAR is the difference in cortisol concentration from the waking sample to the second sample. CDD is the difference between the maximum morning concentration (i.e. the highest of the two morning samples) and the evening sample.

2.13 Statistical analyses

Based on the assessments on the tinnitus formula, the study group was dichotomized into employees with or without tinnitus. All statistical analyses were made using independent samples T-tests with SPSS V.17. The level of significance was set to 5%.

3 Results

Tinnitus was reported among 31 per cent of the included employees (Table 1).

3.1 Tinnitus, gender and age

The prevalence of tinnitus was more pronounced among women (34%) than men (15%). Among women the oldest age group also showed the highest prevalence (Table 1).

Table 1. Prevalence of tinnitus among women and men and different age groups (n = 93).

	Women			Men		
	N	No, tinnitus	Yes, tinnitus	N	No, tinnitus	Yes, tinnitus
Up to 29 years	8	62,5%	37,5%	3	100,0%	0,0%
30 to 39 years	28	75,0%	25,0%	6	83,3%	16,7%
40 to 49 years	20	65,0%	35,0%	2	100,0%	0,0%
50 years and older	24	58,3%	41,7%	2	50,0%	50,0%
Total	80	66,2%	33,8%	13	84,6%	15,4%

3.2 Tinnitus and noise

As seen from Table 2, none of the recorded noise values (stationary/personnel mean dBA or events above 85 dBA) differed significant between the tinnitus and non-tinnitus groups ($p > 0.05$). No significant difference was seen for the difference related to the number of children present at the department.

Table 2. Noise exposure (stationary/personnel mean dBA levels, events above 85 dBA and rated noise levels) and number of children in the study groups reporting and not tinnitus symptoms.

	No, tinnitus	Yes, tinnitus
Mean dB(A)Leq dosimeter	70,7	70,2
Mean dB(A)Leq stationary	63,7	62,9
Mean number of sound events above 85 dBA	66,1	65,2
Mean number of children during the week	13,6	13,4

3.3 Tinnitus and hearing

No significant differences were seen for any of the objective hearing data and the tinnitus and non-tinnitus groups. The tinnitus group however rated their hearing significant more impaired than the non-tinnitus group ($P<0.05$).

Table 3. Audiometric data and rated hearing among employees with and without tinnitus.

	No, tinnitus	Yes, tinnitus
Mean hearing thresholds 2000 Hz and 3000 Hz	12,1	11,9
Mean hearing thresholds 4000 Hz and 6000 Hz	15,3	16,8
Mean hearing thresholds 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz	13,7	14,4
Subjective hearing status	1,4	1,7

3.4 Tinnitus and subjective experiences at work

Mean ratings of different aspects of the sound exposure are summarized in Table 4. Significant differences were seen for worry about the possible effects of the noise on hearing ($p<0.05$) and sound fatigue ($P<0.05$). The tinnitus group also rated the noise levels at work significant higher than the non-tinnitus group ($P<0.05$).

Table 4. Overview of different subjective ratings among the employees reporting and not reporting tinnitus symptoms.

	No, tinnitus	Yes, tinnitus
Rated sound level at work	2,8	3,2
Worry about hearing impairment	2,4	2,8
Sudden changes of the sound level	5,1	5,3
Thinking about the noise	4,3	4,7
Noise annoyance rating	53,9	56,2
Sound fatigue	3,6	4,0

3.5 Tinnitus, fatigue, sleepiness and sleep

No significant differences between the tinnitus and non-tinnitus groups were seen for fatigue or sleepiness. The tinnitus group however rated their sleep quality worse than the non-tinnitus group ($P<0.05$).

Table 5. Differences between the tinnitus and non-tinnitus groups regarding fatigue, sleepiness and sleep.

	No, tinnitus	Yes, tinnitus
SOFI Lack of energy	1,8	1,8
KSS Before sleep	6,8	6,7
KSS After sleep	5,9	6,2
KSD sleep quality index	3,8	3,7

3.6 Tinnitus, headache, chest pressure/pain and shoulder tension/pain

Significant difference between the tinnitus and non-tinnitus groups was seen for chest pressure/pain ($p< 0.05$) shown in Table 6. The difference regarding shoulder tension/pain was closed to significant ($p = 0.06$).

Table 6. Differences between the tinnitus and non-tinnitus groups regarding headache, chest pain and shoulder pain.

	No, tinnitus	Yes, tinnitus
Headache	2,2	2,3
Chest pressure/pain	1,1	1,3
Shoulder tension/pain	2,3	2,7

3.7 Tinnitus, effort/reward and depression

Effort/reward did not differ between the tinnitus and non-tinnitus groups (Table 7). Significant differences were seen for depression, the tinnitus group being more depressed ($p < 0.05$).

Table 7. Overview of effort/reward and depression among the employees reporting and not reporting tinnitus symptoms.

	No, tinnitus	Yes, tinnitus
Effort Reward Imbalance	,5546	,5713
Depression	7,2656	12,6552

3.8 Tinnitus, stress, burn out and cortisol

Employees reporting tinnitus also reported significantly higher levels of burnout symptoms ($p < 0.05$). No significant differences between the two groups were seen for any of the other recorded stress or cortisol values (Table 8).

Table 8. Stress, burnout and cortisol values of the tinnitus and non-tinnitus groups.

	No, tinnitus	Yes, tinnitus
Rated stress at work	2,3	2,4
Burnout	3,0	3,5
Cortisol CAR	5,2	5,0
Cortisol CDD	20,2	20,1

4 Discussion

The overrepresentation of tinnitus among the preschool employees compared to the general population [3], indicates the presence of specific preschool work related factors underlying the symptom. No significant differences however were seen for any of the tested objective exposure parameters or health indicators (noise values and audiometry). The loss of interactions between tinnitus, noise exposure and hearing loss, shown in previous studies [4,5], are probably explained be the relatively low noise levels and limited hearing reductions, observed in the present population. Another contributing factor was the small variation between preschools in the stationary and personal measurements. This meant that individual sensitivity differences probably were more important than exposure differences.

The importance of such individual differences were indicated by a number of differences in subjective ratings between the tinnitus and non-tinnitus groups (experienced noise levels, anxiety for the noise, experienced hearing, sound fatigue, depression and burn out). In all these respects ratings were higher among employees reporting tinnitus symptoms.

The question whether the symptom of tinnitus is explained by these subjective troubles, or if tinnitus is a causal factor provoking these effects be determined by the present study. The study rather speaks for interactions between tinnitus and other subjective troubles.

The results support the ideas about a relationship between tinnitus and experienced ill-health and experienced environmental overload. The relatively low physical noise exposure levels at the preschool departments do not seem to be an isolated causal factor to the tinnitus of the employees. A plausible explanation of the overrepresentation of tinnitus among preschool employees, is rather to be found in the relationships between experienced hearing reduction, fatigue and worry about an overloaded acoustic environment. The consequences and interaction between tinnitus and the mental work load of the employees, verified by burn out symptoms and depression, are of special interest. The way in which chest and shoulder disorders are connected the tinnitus symptoms have under discussion for decades [18]. The conclusions drawn from the study however should be considered in the perspective of the rather limited population and study carried out. Analyses of the interactions between tinnitus and the assumed mental/environmental complexity and overload, should be based on enlarged multi factorial studies.

5 References

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