Hearing thresholds of young workers and conscripts in Switzerland

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INTRODUCTION

In the past decades, considerable efforts have been made to reduce noise in the work environment and improve hearing protection among noise-exposed workers. On the other hand there are concerns about noisy leisure time activities, and an increasing prevalence of noise-induced hearing loss in adolescents is discussed. A recent study in US adolescents (Shargorodsky et al. 2010) showed an increased prevalence of hearing loss in 2005-2006 compared to 1988-1994 but could not show a significant association with noise exposure. In Europe, several studies have been published on the prevalence of hearing loss in young workers (Ising et al. 1988) and in conscripts (Borchgrevink 1998; Job et al. 2000; Jokitulppo et al. 2006; Muhr et al. 2007) and its change over time.

Also in Switzerland, the hearing threshold is routinely tested at conscription for military and in young workers, who will be exposed to high noise levels at work. In order to get a notion of the hearing status of Swiss adolescents, these screening data were analyzed.

There are international standards defining the hearing thresholds to be expected in a population at a certain age for different frequencies. ISO 7029 (2000) describes a screened population without any hearing or ear problems. The thresholds are expressed in dB hearing level (dB HL), whereby 0 dB HL at a given frequency is defined by the sound level half of an 18 year old screened population is able to hear. Distributions of hearing thresholds in different populations can be easily compared.

Hearing loss or hearing impairment on the other hand is defined differently in every publication, which makes a comparison impossible. Hearing loss caused by noise is normally identified by a typical notch at 4-6 kHz in the audiogram.

METHODS

Screening data of young workers

Since 1971 hearing of noise-exposed workers is regularly tested by pure tone audiometry. Also young workers, who were not yet exposed to noise at work, are tested. Since 1994 the hearing threshold of each ear is measured at 0.5, 1, 2, 4, 3, 6, 8 kHz starting at 0 dB HL in steps of 5 dB. Before 1994 the test started at 20 dB HL. The test is performed with a manual audiometer in a soundproof cabin with a Sennheiser HDA200 headset since 1998, before with a Telephonics TDH39 headset.

In the period 1971-2010 144,696 subjects (136,489 males, 8,207 females) at the age of 16-20 years were tested, 46,418 (44,627 males, 1,791 females) of them in the period since 1998 with stable measuring conditions.

Screening data of military conscription

Since 1992 the hearing of the military conscripts is tested by pure tone audiometry. Because the main objective of this screening is the identification of hearing impaired subjects, the test method was not standardized until recently and audiometry started only at 20 dB HL.

Since 2006 hearing threshold of each ear is defined at 0.5, 1, 2, 4, 6, 8 kHz starting at 5 dB HL in steps of 5 dB. The test is performed with an automatic audiometer in a soundproof cabin with a Telephonics TDH39 headset. In the period 1992-2009, 578,806 male subjects were tested, 133,743 of them in the period 2006-2009 with stable measuring conditions.

Hearing loss, hearing impairment

According to WHO[1] the hearing impairment grade is defined by the average hearing level at 0.5, 1, 2, 4 kHz of the better ear. An average of 25 dB HL or better is defined as normal hearing.

In order to identify a noise induced threshold shift (NITS) the individual audiogram (frequency vs. hearing threshold) of each ear is evaluated. A NITS is defined as an audiogram pattern that meets the following criteria for at least one ear (Shargorodsky et al. 2010): hearing threshold (HT) at 0.5 and 1 kHz < 15 dB HL; maximum HT at 3, 4 or 6 kHz at least 15 dB higher than maximum HT at 0.5 and 1 kHz; HT at 8 kHz at least 10 dB lower than the maximum HT at 3, 4 or 6 kHz.

The detection of NITS depends strongly on the starting point of the audiogram. The detection of small NITS at a low level is only possible, if the tested subject is not able to hear the lowest sound-level of the audiometric test. In order to compare data with different starting points, the following simple definition for a high-frequency (HF) hearing loss was used: hearing threshold at 4 or 6 kHz > 25 dB HL, hearing threshold for other frequencies ≤ 25 dB HL.

Average audiogram

For the average audiogram the hearing threshold at each frequency is averaged over both ears of the subject. The quantiles (10 %, 50 %, 90 %) of the distribution are determined for each frequency and displayed as an audiogram of a population.

RESULTS

According to the definition of WHO, 98.7 % of the conscripts (period 2006-2009) and 99.6 % of the young workers (period 1998-2010) have normal hearing.

Figure 1 shows the fraction of subjects with a high-frequency hearing loss in both ears and its change over time. A decline from about 15 % in the seventies to about 2 % in the last decade can be observed. The fraction in conscripts is comparable for the last years with about 2 %.

Figure 2 shows the fraction of young workers with a noise-induced threshold shift. Over the period the fraction is almost stable at about 20 %.

[1] http://www.who.int/pbd/deafness/hearing_impairment_grades/en/index.html (visited 13.5.11)

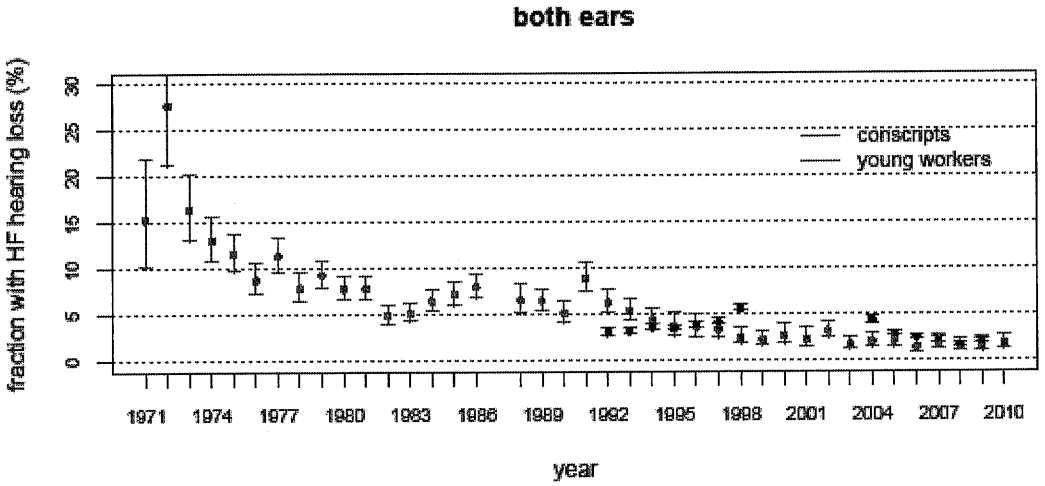

Figure 1: High-frequency hearing loss in young workers and conscripts

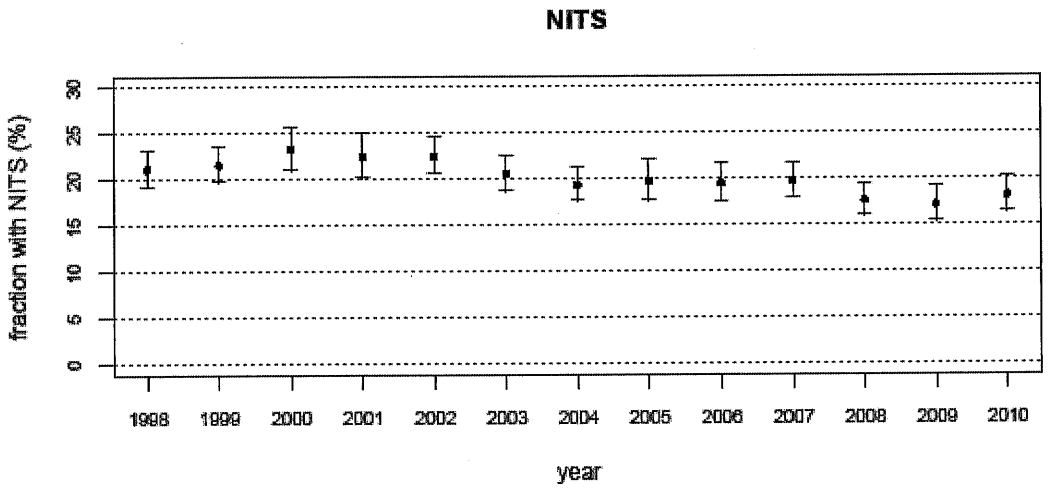

Figure 2: Noise-induced threshold shift in young workers

Figure 3 shows the average audiograms of young male workers (period 1998-2010) of different age. The 10 % and 50 % quantiles of the distribution differ from the ISO 7029 distribution of a screened male population. The 90 % quantile differs only at high frequencies from the standard. For all quantiles, a marked dip at 6 kHz can be observed. Contrary to the ISO 7029 standard, where the hearing threshold distribution does only change minimally between the age of 18 and 20 years (< 1dB), in the young workers a worsening of the hearing with age can be observed. For 10 % of the population with the poorest hearing the decrease between 16 and 20 years is 5 dB for 6 kHz and 2.5 dB for the other frequencies.

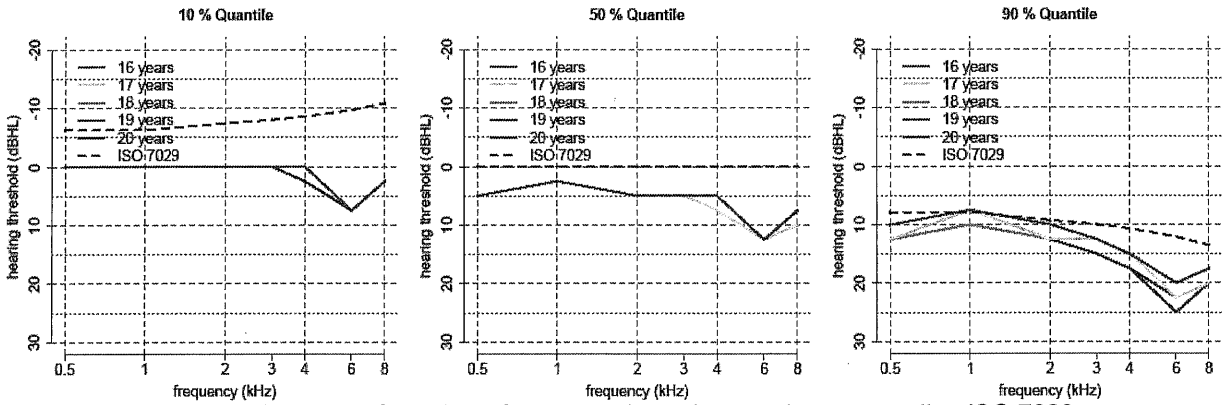

Figure 3: Average audiograms: Quantiles of young male workers and corresponding ISO 7029 curves

DISCUSSION

Swiss adolescents have a good hearing according to WHO criteria. The observed decrease in high-frequency hearing loss over the last 40 years might be explained by an increased awareness in the population and sound level limits not only at work-places but also for music events and in personal music players. Also an improvement in overall health (e.g. less untreated middle ear infections) could have had an effect on the hearing. Nevertheless one has also to keep in mind that the measurement conditions changed over the years, which can strongly influence the results.

The fraction of subjects with NITS strongly depends on the measurement parameters. Because the definition of NITS depends mainly on the shape of the audiogram, the fraction of subjects with NITS depends on the starting point of the audiometric test. Because of the dependence on the hearing threshold at 8 kHz, the fraction of subjects with NITS is high in a young population because of a good hearing at 8 kHz. Also the dependence on the low-frequency hearing threshold can distort the result because it can be influenced by ambient noise and the soundproofing of the cabin. Because of that, the fraction of 20 % NITS in young workers can not be compared to the fraction of 5 % in conscripts, because in the audiometric test for the conscripts the starting point is 5 dB higher and the ambient noise is elevated.

The distribution of the hearing thresholds at different frequencies, the average audiogram, shows a poorer hearing of the young workers compared to the ISO 7029 distribution. ISO 7029 represents a screened population without any ear problems, so any unscreened population as the workers is expected to have poorer hearing. For the 10 % and 50 % quantiles, the starting point of the audiometric test at 0 dB HL instead of -10 dBHL is a severe limitation. The observed dip at 6 kHz is a known problem of the ISO 7029 standard itself (Smith et al. 1999). In the 10 % with poorest hearing (90 % quantile), a much stronger worsening of the hearing with age is observed than expected. This group might be an especially vulnerable population.

Overall it has to be kept in mind that the evaluated data in this study were historical screening data that were collected for a different purpose. It has been suggested (Augustsson & Engstrand 2006) that in screening data the hearing thresholds are elevated compared to regular audiometry.

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Vuvuzelas at South African soccer matches: risks for spectators' hearing

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ABSTRACT

South African Premier Soccer League (PSL) matches are known worldwide as some of the noisiest recreational events. Therefore, the objectives of this study were to i) measure noise levels during different PSL matches; ii) measure changes in auditory function after attending PSL matches; and iii)determine the factors that increase the risk of overexposure to noise during PSL matches. The study used a descriptive quantitative analytical pre- and post-exposure design. Participants (n=19 and n=10) attended two PSL matches. Each participant's auditory function was assessed using distortion product oto-acoustic emissions (DPOAEs) before and after attending a PSL match. Peak sound pressure (L_{Cpk}) and equivalent continuous (L_{Aeq}) levels as well as noise dose were measured during each match. Noise levels recorded during the poorly attended Match 1 were lesser than those of the well-attended Match 2. Participants attending Match 2 had statistically significant reduction in their DPOAE amplitudes after the match (p=0.003) than those attending Match 1. *Vuvuzela* blowers and participants seated within 1 m from them were most at risk of harm to their hearing with significant reduction in DPOAE amplitudes post the match (p=0.002 and p= 0.008, respectively). It was therefore concluded that noise levels at well-attended South African PSL matches pose a significant risk to spectators' auditory function as shown by reduced DPOAE amplitude post match attendance. Three risk factors for overexposure to noise during the match were identified: blowing the *vuvuzela*, close proximity to the individual blowing the *vuvuzela* as well as spectator turnout at the match.

Keywords: *Distortion product oto-acoustic emission, noise exposure, noise-induced hearing loss, soccer match, vuvuzela*

INTRODUCTION

The effects of exposure to loud noises on hearing have been known for centuries, with some of the earliest reports linking noise exposure to hearing loss dating back to the early 1800s (Fosboke 1831; Holt 1882). Much of what is currently known about the effects of exposure to noise on hearing is based on investigations of occupational noise, and less is known about the consequences of other sources of noise. The general public is being increasingly exposed to noise, suggesting that excessive noise exposure will continue to be a major public health concern in the 21st century (Passchier-Vermeer & Passchier 2000).

Modern hobbies such as sporting activities, rifle shooting, and use of personal stereos (under earphones) are known to expose individuals to high levels of noise that may have adverse effects on their hearing and quality of life. In South Africa, soccer matches, in particular, are under the spotlight as social events that expose the public to potentially harmful noise levels. The biggest contributor to noise levels in soccer stadiums across South Africa is the *vuvuzela*, a trumpet-like instrument that is often blown by fans during matches (Staff Writer 2009). The noise made by this instrument