PAN ARCHIVES OF ACOUSTICS
Vol. **41**, No. 3, pp. 535–541 (2016)

DOI: 10.1515/aoa-2016-0052

The Risks of Social Noise Exposure in the Vulnerable Population in Slovakia

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(*received October 31, 2015; accepted May 4, 2016*)

The study is aimed to quantify the effects of social noise exposure (personal music players (PMP), events with high noise exposure) and the exposure to the other environmental noise sources in the selected sample of Slovak university students. The validated ICBEN methodology was used to assess noise annoyance. The measurement of ambient noise levels was done using hand-held sound level analyzer. There were 526 university students (143 males and 383 females, average age 23±2.2) enrolled into the study so far, 192 in the exposed housing facility to road traffic noise and 326 in the control housing facility in Bratislava. The social noise exposure was quantified and followed according to the authorized methodology of the study Ohrkan. From the total sample 416 (79.4%) students reported the use of PMP in the last week for the average time of 314 minutes. There was a significant difference in PMP use between the exposed (85.34%) and the control group (76.31%) ($p = 0.01$). Among PMP users 28.1% exceeded the LAV (lower action value for industry = 80 dB). The results showed the importance of road traffic and the social noise as well and the need for prevention and intervention in these vulnerable groups.

Keywords: social noise exposure; road traffic noise; personal music players; university students.

1. Introduction

Environmental noise has traditionally been dismissed as an inevitable fact of life and has not been targeted and controlled to the same extent as other health risks. A growing body of research linking noise to adverse health effects coupled with proactive legislation, primarily in the EU, is now driving change (Murphy, King, 2014). The environmental noise has often been referred to as the "forgotten pollutant" but is now recognized as an environmental and public health issue which needs to be addressed in modern society (Fritschi *et al.*, 2011; Basner *et al.*, 2014; Murphy, King, 2014).

The social exposure is currently a big issue in adolescents and young adults. Various leisure time activities may be responsible for hearing impairment (temporary or permanent hearing threshold shift, hearing loss) (Sliwinska-Kowalska, Davis, 2012; Pawlaczyk-Luszczynska *et al.*, 2013). Exposure to these noise sources is being compared to the lower action values of noise at work (SCENIHR, 2008, p. 4; Sliwinska-Kowalska, Davis, 2012; Pawlaczyk-Luszczynska *et al.*, 2013; Twardella *et al.*, 2013). The lower action values ($L_{\mathrm{AEX,8h}} = 80$ dB), upper action values ($L_{\mathrm{AEX,8h}} = 85$ dB), and exposure limit values ($L_{\mathrm{AEX,8h}} = 87$ dB) for 8 hours a day and 40 hours a week for occupational noise are stated in the Directive 2003/10/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise) (Directive 2003/10/EC, p. 5). The lower action value is reached by some sources of social noise after less than 30 minutes per week. There are also personal music players (PMP), which at high volume (above 89 dB) reach the noise exposure equivalent to the lower action value after 5 hours per week. We can therefore conclude that personal music players represent a risk to hearing at high sound pressure levels during long-term exposure. From 2.5 to 10 million citizens use the PMP so often and so loudly that they risk hearing loss after five years of use (SCENIHR, 2008, p. 4).

There are not many current data on the usage of PMP among adolescents in Europe and about the empirical evidence on its association with hearing loss. Valuable is the Ohrkan study, an epidemiological study from Bavaria (Regensburg), which follows subjects longitudinally with the purpose of detecting any hearing disorders (Twardella *et al.*, 2013). They have examined 2,240 9th grade students of elementary school in Regensburg by a validated questionnaire elaborated by the Bavarian Health and Food Safety Authority, with particular reference to the quantification of social noise exposure in youth. In collaboration with the University Hospital in Regensburg, Department of Otorhinolaryngology, they objectified hearing examination by tympanometry and audiometry. In the group of examined pupils, 85% of them reported frequent listening to personal music players, 32% of them exceeded the lower action levels by its volume setting and 22% exceeded the upper action levels for noise in the workplace. Listening of PMP was more common in boys than in girls, in pupils from professionally oriented schools and pupils from single-parent families. In a group of pupils with the complete audiometry and tympanometry (n = 1,843), the prevalence of audiometric notches (may indicate hearing loss) was only 2.4% (95% confidence interval 1.7 to 3.1%), suggesting the need to follow subjects longitudinally or also focus on the older age groups, such as college students (Twardella *et al.*, 2013).

Studies on hearing loss of youth and the identification of causes of hearing loss in adolescents are very important in order to develop additional precautions. It is also important to determine which groups of those young and healthy individuals are particularly vulnerable to effectively target the preventive measures.

2. Objective

The study is aimed to quantify the effects of social noise exposure (personal music players, events with high noise exposure) and the exposure to the other environmental noise sources in the sample of university students aged 19–23 years.

3. Methods

The validated methodology according to ICBEN and the Ohrkan study was used (Fields *et al.*, 2001; Twardella *et al.*, 2013). The measurement of ambient noise levels was done using hand-held sound level analyzer.

3.1. Exposure assessment

Maximal, minimal and equivalent sound levels were assessed for both the control and exposed groups living in the Slovakian capital Bratislava by hand-held analyzer Brüel&Kjaer type 2250, with sound level meter software BZ-7222 and frequency analysis software from Brüel&Kjaer. Exposed housing facility – student dormitory, situated near the major transportation route, the main thoroughfare with railway transport, control housing facility – student dormitory in a quiet area with surrounding greenery. All measurements were recorded according to the valid legislation during the time intervals from 17.00–18.00 and from 20.00–21.00 in the exposed and at the same time in the control area. This time interval was chosen to record the afternoon traffic peak and to detect the time most annoying for students and for their activities (studying, watching TV, talking, and falling asleep). Measurements were recorded during spring period at working days (Tuesday) two times on each site. Road traffic flow composition was assessed as well.

3.2. Sample

There were 526 university students (143 males and 383 females, average age 23±2.2) enrolled into the study so far, 192 in the exposed area and 326 in the control area. Students significantly did not differ by gender, but they differed by age (older in the control area), flat location in relation to noise exposure, position of a flat in the floor height, length of stay in the given area, windows orientation, windows types and satisfaction with flat surrounding. The respondents have been living in the given area at least for four years.

3.3. Noise annoyance questionnaire

Subjective response was assessed by the authorized "Noise annoyance questionnaire", the different sources of environmental noise were quantified (Sobotova *et al.*, 2001). The validated 5 grade noise annoyance verbal scale (Not at all, Slightly, Moderately, Very, Extremely) was developed and recommended by experts from the noise research ICBEN (The International Commission on the Biological Effects of Noise) team (Fields *et al.*, 2001).

The questionnaire comprised personal (age, gender, education), behavioural (smoking, coffee and alcohol consumption) and questions focused on the characteristics of residential environment (localization, construction and surrounding of residential buildings, the location and amenities of the apartment, window orientation to quiet or noisy streets and the length of stay in the apartment). It also included questions on possible non-auditory health effects (noise annoyance from different sources, interference with various activities and sleep disturbance) and subjective assessment of health troubles (headache, nervousness and irritability, difficulties in falling asleep, the use of different types of medications, the presence cardiovascular diseases and overall assessment of the health status). A special section is dedicated to traffic noise annoyance and its psychological and physiological effects as well as the social noise exposure (personal music players (PMP), events with high noise exposure). The intensity and duration of exposure was subjectively assessed, as well as the type of headphones. In the end, respondents were asked if they have complained on noise annoyance and disturbance and about the corrective actions implemented in the house to reduce noise exposure. Information from respondents was obtained by personal interview. Response rate of the questionnaire was 90%.

3.4. Social noise exposure

Social noise exposure was quantified by subjective assessment of intensity and frequency of listening to personal music players and the duration of time spent at events with high noise exposure – playing the music instrument, visiting cinema, classical, rock, pop, jazz concerts, discotheques, entertainment facilities, sport events, noisy household and garden work). The authorized methodology was based on the Ohrkan study (Twardella *et al.*, 2013). The conversion of the subjective assessment of the volume setting and duration of exposure to personal music players according to Portnuff *et al.* (2011; 2013) were used to estimate the exposure dose (the intensity of noise exposure in dB). The duration and frequency of PMP listening were assessed in the course of one week, as well as the loudness level and the type of headphones (headset, earphones, earbuds). The duration of time (hours and minutes per week or month) spent at events with high noise exposure - entertainment facilities, discotheques, concerts of different music styles (classic, rock, pop, jazz), sport activities, playing the music instrument and noisy household and garden work was assessed subjectively as well.

3.5. Statistical analysis

Statistical evaluation comprises the methods of descriptive statistics, the relationships between continuous variables were examined by bivariate analysis, t-test, analysis of variance (ANOVA) and correlation coefficients. Relationships between categorical data were evaluated by contingency tables, chi-square test and stratified analysis. Statistical packages Epi Info$^{\text{TM}}$, Version 7.1.1.1, 2013 and S-Plus 6.0 were implemented.

4. Results

The monitoring of sound levels in the exposed area showed the levels above the national and international limits in the afternoon and in the evening time interval (17.00–18.00 and 20.00–21.00) (Berglund *et al.*, 2000; Slovak Ministry of Health Decree No. 549/2007; Hurtley, 2009). Sound levels in the control area were significantly lower ($p < 0.001$). The higher sound levels in the evening interval could be due to other noise sources (e.g. entertainment facilities) (Tables 1, 2).

In the composition of the traffic flow, the number of passenger cars and trams, which are considered to be particularly annoying, was predominant. In the composition of the traffic flow in the control area the number of passenger cars was also predominant, however, not in such numbers as in the exposed area; there were buses and lorries, but no trams (Tables 1, 2).

Students in the exposed housing facility were significantly more annoyed by road traffic noise ($\text{OR}_{MH}=4.12$, 95% CI=2.97−5.68), by railways noise (trams) ($\text{OR}_{MH} = 2.02$, 95% CI = 1.58−2.60), noise from industry ($\text{OR}_{MH} = 2.36$, 95% CI = 1.88−2.95), noise from neighbourhood ($\text{OR}_{MH} = 1.62$, 95% CI = 1.33−1.96) and entertainment facilities ($\text{OR}_{MH} = 4.09$, 95% CI = 3.25−5.15); there was not signifi-

Table 1. Time dynamics of sound levels in the exposed housing facility, April 2014.

Time intervals	Sound level $L_{A\,\min}$ [dB]	Sound level $L_{A\,\max}$ [dB]	Sound level L_{Aeq} [dB]	Road traffic flow composition
17.00–18.00	53.2	85.8	67.6	A 5460, B 36, L 60, T 72
20.00–21.00	49.0	82.4	64.7	A 4644, B 12, L 12, T 60

Legend: A – automobile, B – bus, L – lorry, T – tram

Table 2. Time dynamics of sound levels in the control housing facility, April 2014.

Time intervals	Sound level $L_{A\,\min}$ [dB]	Sound level $L_{A\,\max}$ [dB]	Sound level L_{Aeq} [dB]	Road traffic flow composition
17.00–18.00	41.6	69	53.4	A 108, B 12, L 0, T 0
20.00–21.00	44.8	73.5	54.3	A 60, B 12, L 0, T 0

Legend: A – automobile, B – bus, L – lorry, T – tram cant difference concerning noise annoyance from the house construction and aircraft noise (Table 3, Fig. 1).

Table 3. Annoyance risks from community noise sources (year 2014).

Noise annoyance (type of noise)	Risks in 2014
	OR (95% CI)
Road traffic	$^{+}$ 4.12 (2.97–5.68)***
Neighbourhood	$^{+}$ 1.62 (1.33–1.96)***
Entertainment facilities	$^{+}$ 4.09 (3.25–5.15)***
House construction	$^{+}$ 0.95 (0.89–1.82)
Railways	$^{+}$ 2.02 (1.58–2.60)***
Aircraft	1.15 (0.81–1.64)
Industry	$^{+}$ 2.36 (1.88–2.95)***

Legend: *** $p < 0.001$; $^{+}$ Mantel-Haenszel weighted odds ratio; CI = confidence interval; OR = odds ratio

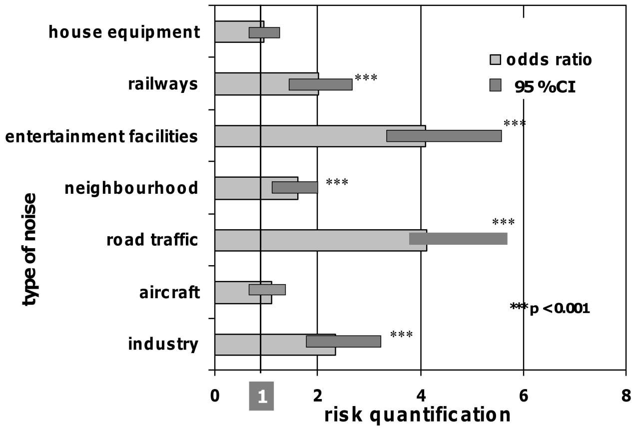

Fig. 1. Annoyance risks from community noise sources (year 2014).

From the total sample of 526 responding students 416 (79.4%) reported listening to PMP in the last week for the average time of 314 minutes. There was a significant difference in PMP use between the exposed (85.3%) and the control group (76.3%) ($p = 0.01$) (Table 4, Fig. 1), but it was not significant between gen-

Table 4. The use of PMP and the noisy leisure events in the sample groups of university students.

Variable	Exposed group* ($n = 192$)		Control group* ($n = 326$)		P-value
	N	%	N	%	
Gender					
Male	57	29.7	86	26.4	0.42
Female	135	70.3	240	73.6	
Age**					
Male	22.8 ± 1.5		23.9 ± 2.6		**0.008**
Female	22.6 ± 1.0		23.2 ± 2.6		**0.013**
The use of PMP in the last week (subjectively)					
No	28	14.7	77	23.7	**0.014**
Yes	163	85.3	248	76.3	
Loudness of PMP music					
1 Not louder than speech	25	15.3	59	23.5	0.20
2 Could hear the talk	73	44.8	94	37.5	
3 Could hear the traffic	46	28.2	68	27.1	
4 Could not hear either talk or traffic	19	11.7	30	11.9	
Type of headphones					
Earbuds	149	90.3	207	82.5	**0.03**
Headset	16	9.7	44	17.5	
Other noisy events and activities (min/month)***					
Playing music instrument	427.3 ± 588.6		544.3 ± 765.5		0.44
Cinema	262.8 ± 766.4		155.2 ± 83.1		0.09
Classical music concerts	138.5 ± 70.9		141.9 ± 144.4		0.94
Rock, pop, jazz concerts	314.4 ± 625.9		240.0 ± 236.2		0.40
Discotheques	475.3 ± 773.5		469.1 ± 685.2		0.95
Sport events	470.5 ± 429.9		633.0 ± 1150.5		0.41
Household/garden work	455.1 ± 850.5		477.6 ± 781.6		0.73

* There are missing values for each variable category

** Average age in the sample (arithmetic mean ± standard deviation)

*** Average number of minutes per month (arithmetic mean ± standard deviation)

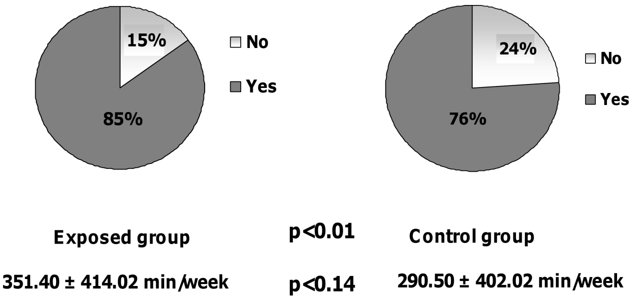

Fig. 2. Listening to PMP in minutes during the last week in the observed areas.

ders ($p = 0.43$) and in the duration of listening to PMP ($p = 0.14$).

More than 10% of students listen to the music on the loudness level 4 (they cannot hear the speech or even the traffic) and more than 80% (84.68%) use earbuds. There was not significant difference between the loudness level of PMP or in the duration of time spent at most events with high noise exposure between the exposed and control group.

The significant difference was in the type of headphones: earbuds are more often used by students from the exposed area ($p = 0.03$). Ear bud insert phone types are more harmful according to SCENIHR (2008) and increase the sound level by 7–9 dB (Table 4).

The presence of subjective hearing impairment of PMP users was significantly higher (26%), than in the non-PMP users (16%) ($p < 0.03$) (Fig. 3).

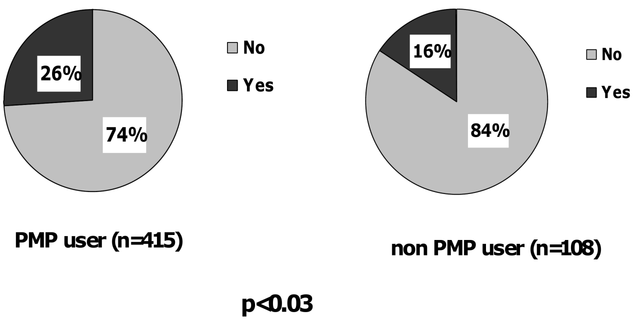

Fig. 3. Subjective hearing impairment among PMP users and non users.

The self-reported usual volume setting was used to derive the mean sound pressure level according to Portnuff *et al.* (2011; 2013). The mean sound pressure level associated with the reported duration of use was transformed into an energy equivalent sound pressure level associated with duration of 40 hours per week. The equivalent sound pressure level, derived as described above, was compared to work noise limits (lower action value LAV = 80 dB) (Twardella *et al.*, 2013).

Among PMP users 28.1% exceeded the LAV, 27.2% in the exposed area and 28.8% in the control area ($p = 0.65$), 34.6% males and 33.7% females ($p = 0.23$) (Figs. 4 and 5).

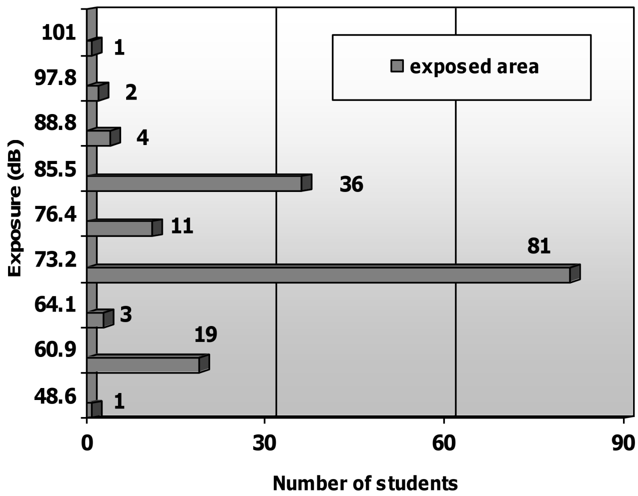

Fig. 4. The estimation of exposure dose from PMP in the exposed area.

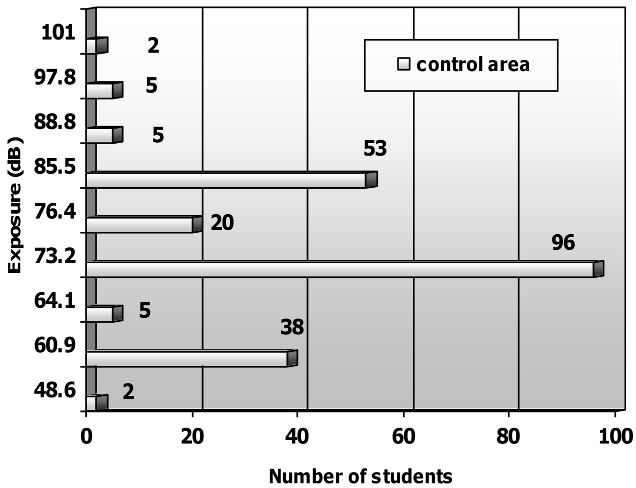

Fig. 5. The estimation of exposure dose from PMP in the control area.

Among noisy activities students spent most of their time visiting sport events (560.4±901.5 minutes/month), discotheques (469.9±719.9 minutes/month), playing the music instrument (498.5±705 minutes/month) and at household/garden work 467.1±803.3 minutes/month). There was not significant difference between the duration of time spent at events with high noise exposure between the group of students exposed to road traffic noise and the control group (Table 4).

5. Discussion

Our findings are consistent with the findings of other studies reporting 88–90% of teenagers and young adults listening to PMPs through earphones (Basner et al., 2015). A number of papers published over the years 2011–2013 estimated the risk of hearing loss due to the use of PMPs, as well as the actual incidence of hearing loss and tinnitus in the exposed populations. The studies were carried out among German, American, Italian, Dutch, Slovenian, Brazilian, and Malaysian teenagers and young adults (Vogel *et al.*, 2010; Figueiredo *et al.*, 2011; Portnuff *et al.*, 2011, 2013; Pellegrino *et al.*, 2013; Sulaiman *et al.*, 2013; Twardella *et al.*, 2013; Jeram, Delfar, 2014).

The maximum sound pressure level of the PMPs through in-ear earphones reached 126 dB, with a 14.4 dB difference depending on the style of music (Basner *et al.*, 2015). Mean preferred listening levels (L_{eq}) varied widely within the range 68–86 dB, depending on the population, background noise, type of music, and method of measurement. Self-reported mean daily use ranged 0.014–12 h (Basner *et al.*, 2015). In the recent study from Argentina on 172 14–15 years old adolescents from a technical high school a significant difference was found between low and high noise exposure, showing higher hearing threshold levels (HTL) in high exposure. The sound immissions measured in nightclubs 107.8–112.2 dB and PMPs 82.9–104.6 dB revealed sound levels risky for hearing health according to exposure times (Serra *et al.*, 2014). These studies demonstrate the need to implement preventive and hearing health promoting actions in adolescents.

The percentage of teenagers and young adults at risk of developing noise induced hearing loss (NIHL) was estimated to be between 17% and almost 29% (Basner *et al.*, 2015). Hearing loss of $\geq$25 dB at one or more frequencies was found in 7.3% among 177 Malaysian PMP users (Sulaiman *et al.*, 2013). In a Bavarian group of 9th grade students ($n = 1\,843$), the prevalence of audiometric notches was only 2.4% suggesting the need to follow subjects longitudinally or also focus on the older age groups, such as university students (Twardella *et al.*, 2013).

The results of the study in Slovenia showed that nearly 12.4% of students of age 12 to 19 (out of the 1 635 respondents from elementary and high schools in Slovenia), might be at risk for permanent hearing damage if they persist in their frequent and long lasting listening of loud music, using PMP. The risk was increasing with students' age up to second grade of high school and decreasing for the group of the oldest students (Jeram, Delfar, 2014).

In our study, university students from the traffic noise exposed group were listening to PMP more often than students from the control group (possibly trying to mask the effect of the other sources of environmental noise). However, the level of loudness in PMP listening was not significant between groups as well as the duration of time spent at events with high noise exposure. These results are difficult to compare with the results of the other relevant studies, because we are not aware of any studies which have been researching such associations by now.

In the future, we would like to enlarge our study sample and to add a population group of adolescents in the age of 15–17 years. In cooperation with the experts of Pediatric Otorhinolaryngology we would like to perform audiometric, tympanometric and other objective examinations to determine hearing loss and to objectify the effects of social noise exposure on the hearing organ. Hearing loss may be detected either by pure-tone audiometry quantifying overall hearing loss or otoacoustic emissions (OAEs) detecting cochlear status where hearing loss caused by outer hair cells (OHCs)' dysfunction can be inferred. OAEs may be particularly useful for detecting NIHL since the OHC are known to be the most vulnerable elements of auditory processing with respect to noise overexposure (Marshall *et al.*, 2001; Serra *et al.*, 2014). Within the quantification of the environmental noise effects, we will explore the risk of chronic diseases in more detail in teenagers and in young adults.

6. Conclusion

In our study 79.4% of respondents reported listening to personal music players (PMP) in the last week for the average time of 314 minutes. Among PMP users 28.1% exceeded the LAV. There was a significant difference in the numbers of PMP users between the groups of different traffic noise exposure. There was not significant difference between the duration of time spent at events with high noise exposure between the group of students exposed to road traffic noise and the control group.

The results of the study showed the importance of road traffic and the social noise as well. After the finalization of the study results, we would like to formulate the proposals and interventional procedures and effectively target the preventive measures (education, the use of noise-cancelling headphones for PMP users) in the vulnerable groups of teenagers and young adults and their parents and teachers as well.

Acknowledgment

This contribution is the result of the research supported by the ESF-OPV project "MPH study programme development at Comenius University in Bratislava in English language (Master of Public Health)". ITMS code of the project: 261402300093.

The research was also partially supported by grant Y.A.B.S. (Youth and Parents Behavioral Survey in Slovakia) O-15-101-/0001-00.

References

1. Basner M., Babisch W., Davis A., Brink M., Clark C., Janssen S., Stansfeld S. (2014), *Auditory and non-auditory effects of noise on health*, Lancet, **383**, 154–168.
2. Basner M., Brink M., Bristow A., de Kluizenaar Y., Finegold L., Hong J., Janssen S.A., Klaeboe R., Leroux T., Liebl A., Matsui T., Schwela D., Sliwinska-Kowalska M., Sörqvist P. (2015), *ICBEN review of research on the biological effects of noise 2011–2014*, Noise Health, **17**, 57–82.
3. Berglund B., Lindvall T., Schwela D.H. (2000), *Guidelines for Community Noise*, WHO, Geneva.
4. Council Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks. Official Journal of the European Communities L 42, 15.2.2003, p. 38
5. Murphy E., King E.A. (2014), *Environmental Noise Pollution. Noise Mapping, Public Health, and Policy*, Elsevier, Burlington, USA.
6. Fields J.M., de Jong R.G., Gjestland T., Flindell I.H., Job R.F.S., Kurra S., Lercher P., Vallet M., Yano T., Guski R., Felscher-Suhr U., Schumer R. (2001), *Standardized general-purpose noise reaction questions for community noise surveys: Research and recommendation*, Journal of Sound and Vibration, **242**, 641–679.
7. Figueiredo R.R., Azevedo A.A., Oliveira P.M., Amorim S.P., Rios A.G., Baptista V. (2011), *Incidence of tinnitus in mp3 player users*, Brazilian Journal of Otorhinolaryngology, **77**, 293–298.
8. Fritschi L., Brown L.A., Kim R., Schwela D., Kephalopoulos S. (2011), *Burden of disease from environmental noise. Quantification of healthy life years lost in Europe*, WHO, Geneva.
9. Hurtley Ch. (Ed.) (2009), *Night noise guidelines for Europe*, WHO, Geneva.
10. Jeram S., Delfar N. (2014), *Preliminary results of the study on usage of portable music players and future plans for public policy in Slovenia*, Proceedings of the 11th International Congress on Noise as a Public Health Problem (ICBEN), Nara, Japan.
11. Marshall L., Lapsley Miller J.A., Heller L.M. (2001), *Distortion-product otoacoustic emissions as a screening tool for noise-induced hearing loss*, Noise Health, **3**, 43–60.
12. Pawlaczyk-Luszczynska M., Dudarewicz A., Zaborowski K., Zamojska M., Sliwinska-Kowalska M. (2013), *Noise induced hearing loss: Research in central, eastern and south-eastern Europe and newly independent states*, Noise and Health, **15**, 55–56.
13. Pellegrino E., Lorini C., Allodi G., Buonamici C., Garofalo G., Bonaccorsi G. (2013), *Music-listening habits with MP3 player in a group of adolescents: A descriptive survey*, Annali di Igiene: Medicina Preventiva e di Comunita, **25**, 367–376.
14. Portnuff C.D.F., Fligor B.J., Arehart K.H. (2011), *Teenage Use of Portable Listening Devices: A Hazard to Hearing?*, Journal of the American Academy of Audiology, **22**, 663–677.
15. Portnuff C.D.F., Fligor B.J., Arehart K.H. (2013), *Self-report and long-term field measures of MP3 player use: How accurate is self-report?*, International Journal of Audiology, **52**, S33–S40.
16. SCENIHR (2008), *Potential health risks of exposure to noise from personal music players and mobile phones including a music playing function: Scientific Committee on Emerging and Newly Identified Health Risks*, European Commission, Brussels.
17. Serra M.R., Biassoni E.C., Hinalaf M., Abraham M., Pavlik M., Villalobo J.P., Curet C., Joekes S., Yacci M.R., Righetti A. (2004), *Hearing and loud music exposure in 14–15 years old adolescents*, Noise Health, **16**, 320–30.
18. Sliwinska-Kowalska M., Davis A. (2012), *Noise-induced hearing loss*, Noise and Health, **14**, 274–80.
19. Slovak Ministry of Health Decree No. 549/2007, *Establishing details on the permissible levels of noise, infrasound and vibration and on the requirements for the objectification of noise* [in Slovak], Infrasound and Vibration in the Environment.
20. Sobotova L., Jurkovicova J., Volekova J., Aghova L. (2001), *Community noise annoyance risk in two surveys*, International Journal Occupational Medicine and Environmental Health, **14**, 197–200.
21. Sulaiman A.H., Seluakumaran K., Husain R. (2013), *Hearing risk associated with the usage of personal listening devices among urban high school students in Malaysia*, Public Health, **127**, 710–715.
22. Twardella D., Perez-Alvarez C., Steffens T., Bolte G., Fromme H., Verdugo-Raab U. (2013), *The prevalence of audiometric notches in adolescents in Germany: The Ohrkan-study*, Noise and Health, **15**, 412–419.
23. Vogel I., Verschuure H., van der Ploeg C.P.B., Brug J., Raat H. (2010), *Estimating adolescent risk for hearing loss based on data from a large school-based survey*, American Journal of Public Health, **100**, 1095–1100.