 doi:10.20944/preprints201911.0388.v1

Article

Social Noise Exposure in the Sample of Slovak University Students

Alexandra Filova [1], Jana Jurkovicova [1], Katarina Hirosova [1], DianaVondrova [1], Barbora Filova [2], Martin Samohyl [1], Jana Babjakova [1], Juraj Stofko [3], Lubica Argalasova [1,]

1 Institute of Hygiene, Faculty of Medicine, Comenius University, 81499 Bratislava, Slovakia; alexandra.filova@fmed.uniba.sk (A.F.), jana.jurkovicova@fmed.uniba.sk (J.J.), katarina.hirosova@fmed.uniba.sk (K.H.), diana.vondrova@fmed.uniba.sk (D.V.); martin.samohyl@fmed.uniba.sk (M.S.), jana.babjakova@fmed.uniba.sk (J.B.),

2 Institute of Medical Physics, Biophysics, Informatics and Telemedicine, Faculty of Medicine, Comenius University, Sasinkova 2, 813 72 Bratislava, Slovakia; barbora.filova@fmed.uniba.sk (B.F.),

3 Institute of Physiotherapy, Balneology and Medical Rehabilitation, University of Ss. Cyril and Methodius in Trnava, 91701 Trnava, Slovakia; juraj.stofko@gmail.com (J.S.)

* Correspondence: lubica.argalasova@fmed.uniba.sk; Tel.: +421-905-209-114

Abstract: Purpose: The study is aimed to quantify the effects of social noise (personal music players (PMP), high-intensity noise exposure events) and road traffic noise exposures in the sample of Slovak university students living and studying in Bratislava. Methods: There were 1,003 university students (306 males and 697 females, average age 23.13±2) enrolled in the study; 347 lived in the student housing facility exposed to road traffic noise (L_{Aeq} =67.6 dB) and 656 in the control one (L_{Aeq} =53.4 dB). Respondents completed a validated ICBEN 5-grade scale "Noise annoyance questionnaire". The exposure to PMP was objectified by the conversion of the subjective evaluation of the volume setting and duration. With the cooperation of the ENT specialist, we arranged audiometric examinations on the pilot sample of 41 volunteers. Results: From the total sample of 1,003 students, 794 (79.16 %) of them reported the use of PMP in the course of the last week; average time of 285 minutes. There was a significant difference in PMP use between the exposed (85.59 %) and the control group (75.76 %) (p=0.01). Among PMP users 30.7 % exceeded the LAV (lower action value for industry $L_{Aeq,8h}$ = 80 dB). On a pilot sample of volunteers (n=41) audiometry testing was performed indicating hearing threshold shift at higher frequencies in 22% of subjects. Conclusions: The results of the study on a sample of young healthy individuals showed the importance of exposure to environmental noise from different sources (transportation, neighbourhood, construction, entertainment facilities, etc.) as well as social noise and the need for prevention and intervention.

Keywords: social noise, auditory, non-auditory noise effects, personal music players, university students

1. Introduction

The growing impact of exposure to environmental noise on health is one of the major health risks of the present time. It concerns mainly the population living in urban areas, where there is a high level of traffic noise and the noise from other sources, such as construction, industry, entertainment facilities and neighbourhood [1 - 4]. This negative factor of the environment is different from other pollutants, its levels are still increasing and it affects humans constantly, during the time specified for relaxation and sleep. Noise levels annoy people also during recreation, leisure time or at social activities [5-8]. The range of issues that may be associated with exposure to excessive noise is really wide. Prolonged exposure to environmental noise in the range between 60 - 90 dB can promote non-specific reactions of the organism, especially in the vegetative, endocrine and regulatory field [1,7, 9-12].

In addition to exposure to environmental noise, the voluntary or social noise exposure is very important nowadays. This type of exposure is currently a major problem, especially among adolescents and young adults. Various leisure time activities (often listening to music on high-volume level with personal music players (PMP) and regular visiting of events with high noise exposure intensity), can have auditory (temporary or permanent hearing threshold shift, hearing loss), or non-auditory effects on individuals (annoyance, sleeping disorders, nervousness, irritability, high blood pressure) [1, 3, 7, 13].

Hearing loss due to noise exposure is the most common cause of deafness and hearing impairment. Although genetics and advanced age are the main risk factors, temporary and permanent hearing impairment is increasingly common among young adults and children, mainly due to increased exposure from personal music players and noisy leisure time activities [7].

Excessive listening to personal music players often leads to the shift of hearing thresholds. The development of new technologies brings to market devices that can produce sound at high levels and thus cause considerable damage to the hearing organ. Hearing damage is the most common in people who listen to music on PMP for more than 5 years. In Europe there is 2.5 to 10 million listeners to PMP and the most are children and young people. Estimated unit sales ranged between 184-246 million for all portable audio devices and between 124-165 million for MP3 players [14].

Listening to loud music from the portable music players at least five hours a week exceeds the noise standards to which workers may be exposed in the noisiest industrial enterprises. By inserting the earphones into the ear, the hearing canal closes and the intensity of the sound - music increases. These values are detrimental to longer and stronger PMP listening. It is not only about the music but also about any sound with a higher volume [15, 16].

The study is aimed to quantify the effects of social noise exposure (personal music players (PMP), high intensity noise exposure events) and road traffic noise in the sample of Slovak university students living and studying in the Slovak capital Bratislava.

2. Materials and Methods

The research was conducted at the Institute of Hygiene Faculty of Medicine Comenius University in Bratislava, Slovakia. We used the method of subjective evaluation using a standardized anonymous questionnaire and methods of objectification by direct measurement of noise levels using hand-held sound analyser with the frequency analysis software.

2.1. Study Subjects

The sample comprised 1,003 subjects, 697 (69.49%) females and 306 (30.51%) males. The average age was 23.13 ± 2 years. All students had temporary residence in Bratislava, Slovakian capital at least for four years. Probands from the exposed group stayed at the college dormitory Druzba Comenius University (CU). This group included 347 (34.60%) subjects. Probands from the control group stayed at the college dormitory of Ludovit Stur, Stare Grunty, CU. This group included 656 (65.40%) university students. Exposed housing facility – student dormitory is situated near the major transportation route, the main thoroughfare with railway transport; control housing facility – student dormitory in a quiet area with surrounding greenery. Probands significantly differed by age, by traffic noise exposure, flat location in relation to noise exposure, position of a flat in the floor height, length of stay in the given area, the orientation and the type of windows, the satisfaction with flat surrounding and the use of personal music players (PMP) (Table 1).

Table 1. Characteristics of the Students' Sample.

 doi:10.20944/preprints201911.0388.v1

Variable	Exposed group* (n=347)		Control group* (n=656)		P-value
	N	%	N	%	
Gender					
Male	102	29,4	204	31	0.28
Female	245	70,6	452	69	
Age**					
Male	23,13 ± 2.00		23.14 ± 2.00		**0.76**
Female	23,13 ± 2.00		23.14 ± 2.00		
The use of PMP in the last week (subjectively)					
No	50	14.41	159	24.24	**0.0002**
Yes	297	85.59	497	75.76	
Loudness of PMP music					
1 Not louder than speech	43	14	96	19	**0.0002**
2 Could hear the talk	129	43	181	36	
3 Could hear the traffic	84	28	145	29	
4 Could not hear either talk or traffic	44	15	82	16	
Type of headphones					
Earbuds	273	91	428	84	**0.01**
Headset	27	9	82	16	
Other noisy events and activities (min/month)***					
Playing music instrument	548 ± 884		551 ± 887		0.38
Visit to the cinema	228 ± 359		228± 359		0.32
Visit of classical concerts	203 ± 238		205 ± 235		0.26
Visit of rock, pop, jazz concerts	305 ± 464		302 ± 458		0.06
Visit of discotheques	544 ± 776		543 ± 767		0.30
Visit of sport events	483 ± 777		483 ± 777		0.89

* 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)

2.2. Noise annoyance questionnaire

We used a validated methodology for subjective evaluation of noise annoyance and interference with various activities. We assessed the quality of sleep and psychosocial well-being in relation to noise exposure. Respondents filled in validated "Noise annoyance questionnaire", using a standard 5-point scale (0 = not at all, 1 = slightly, 2 = moderately, 3 = very, 4 = extremely) developed and recommended by experts from the ICBEN (The International Commission on the Biological Effects of Noise) team [17, 18]. We focused mainly on sleep disturbance, noise annoyance from various sources and interference with various activities. Questionnaires and objective examinations were voluntary for each of the respondents. Study participants gave their informed consent to use the information for research purposes.

 doi:10.20944/preprints201911.0388.v1

2.3. Exposure assessment

We used the method of objectification by direct measurement of noise levels using hand-held sound analyser Brüel-Kjaer 2250 with the frequency analysis software. We measured equivalent sound levels in the exposed and also in the control area. All measurements were recorded according to the valid Slovak 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. [18] 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.

2.4. Exposure from social noise

In the estimation of exposure from PMP we used the methodology of Portnuff et al. [19, 20]. Respondents rated subjective intensity and frequency of exposure to personal music players (PMPs). We examined what type of headphones they prefer (earphones or headphones) and at what volume level they listen to their PMPs. They also rated how often they attend events with high intensity noise exposure (e.g. rock concerts, discos, sport events) and how often they do noisy housework and whether they play a musical instrument).

2.5. Hearing Examination

Hearing examination was provided for volunteers in the cooperation with ENT specialists in the out-patient Department for Otorhinolaryngology in Bratislava. The probands were examined by subjective audiometric method in which the hearing was checked by electro-acoustic device – audiometry. The basic examination of the threshold tone audiometry established a threshold hearing for pure tones (lowest stimulus intensity). For determining the hearing threshold for pure tones the diagnostic audiometer MAICO MA 52 was used. This audiometer allows to investigate overhead lines at frequencies of 250-6000 Hz and bone conduction at frequencies 500-1000-2000-4000 Hz. During the examination the probands were set into a quiet chamber, respectively audiometric cabin in the medical office. The chamber is used for audiometric testing tone audiometry, in particular for determining the hearing threshold for pure tones and meeting the essential parameters, in particular the desired attenuation of the intensity of sounds. It corresponds to ISO 266: 1997 and ISO 389-3: 2016.

2.6. Statistical Analysis

To evaluate the results, we used the methods of descriptive and analytical statistics to identify mutual associations between lifestyle factors, psychosocial, biological, behavioral and environmental factors and statistical package Epi InfoTM software, version 7.1.5.0, Atlanta, USA, and SPSS, version 24 (International Business Machines Corp.; New Orchard Road; Armonk, New York, USA).

3. 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 (L_{Aeq}=67.6; 64.7 dB). Sound levels in the control area were significantly lower ($p<0.001$) (L_{Aeq}=53.4; 54.3 dB) [9, 18]. The higher sound levels in the evening interval in the control area could be due to the other noise sources (e.g. entertainment facilities) (Table 2).

Table 2. Sound levels in the exposed and control housing facility.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 November 2019 doi:10.20944/preprints201911.0388.v1

Time intervals (h)	Sound levels in the exposed housing facility [L_{Aeq}] dB	Sound levels in the control housing facility [L_{Aeq}] dB
17.00-18.00	67.6	53.4
20.00-21.00	64.7	54.3

In addition to monitoring the noise levels, we evaluated the traffic flow (Table 3 and 4). In the exposed area passenger cars dominated, followed by trams, buses, and motorcycles. The transport intensity corresponds to the results of noise levels measurements. In the control area, most of the vehicles were passenger cars, then buses, trucks and motorcycles.

Table 3. Traffic flow in exposed area at different time intervals.

Time interval	17.00-18.00	20.00-21.00
Automobiles	6,470	3,770
Tram	110	60
Motorcycles	0	24
Bus	40	24
Lorry	20	0

Table 4. Traffic flow in control area at different time intervals.

Time interval	17.00-18.00	20.00-21.00
Automobiles	420	204
Tram	0	0
Motorcycles	0	0
Bus	12	12
Lorry	12	0

When comparing the results of noise level monitoring and traffic flow assessment, we can assume that students from the control site are exposed more to noise from entertainment facilities rather than traffic.

The indicators estimated from Bratislava strategic noise map were L_{DEN}=66±2 dB vs L_{DEN}=56±4 dB ($p<0.05$) (http://www.laermkarten.de/bratislava/) [21].

From the total sample of respondents, 794 (79.16%) students reported listening to PMP in the last week for the average time of 285 minutes. There was a significant difference in PMP use between the exposed group to road traffic noise (85.59 %) and the control group (75.76 %) (p=0.0002) and also in the duration of listening to PMPs in minutes (286±367 vs 292±367) ($p<0.55$), but it was not significant between genders (p=0.08).

About 16 % of students listen to the music on the loudness level 4 (they cannot hear the speech or even the traffic) and 86.5% 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 (more than 90 % of students) (p=0.01). Earbud insert phone types are more harmful according to SCENIHR (2008) and increase the sound level by 7-9 dB [14]. Based on the subjective assessment the reduced hearing ability indicated 25.72 % of subjects from exposed location and 22.02 % of subjects in the control location (p=0.23). The presence of subjective hearing impairment of PMP users was not significantly higher (23.99 %), compared to the non-PMP users (20.67 %) (p=0.4).

From activities with high intensity of noise exposure most students took part in household and garden work (n=756), where they spent on average 481 minutes. The second most frequent activity was visiting a cinema (n=514), where students spent on average 227 minutes per month. The third one was visiting discotheques (n=437) where they spent on average 544 minutes per month. The fourth most preferred activity was visiting of sport events (n=242) where they spent on average 538 minutes per month. Students spent 556 minutes playing musical instrument (n=215). Most of the time, subjects (n=206) devoted to rock, pop and jazz concerts, where they spent on average 302 minutes per month. Students spend 203 minutes visiting classical music concerts (n=90) and 191 minutes in sport shooting (n=18) (Figure 1).

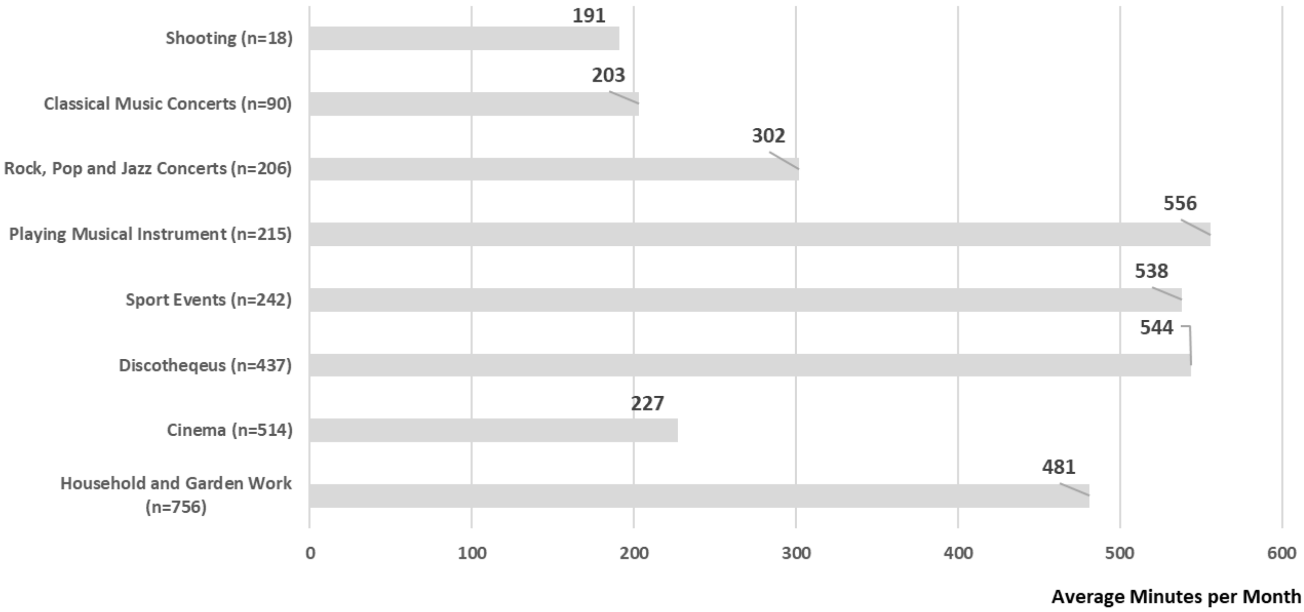

Figure 1. Number of students taking part in leisure time activities (average minutes per month).

Students from the exposed group to road traffic noise spent in the cinema about 244 minutes per month, compared with subjects in the control group who spent in the cinema on average 170 minutes per month (p=0.08). There was no significant difference between the duration of time spent at the other events with high noise exposure between the exposed and the control group.

In cooperation with the ENT specialist we performed audiometric testing on a pilot sample of volunteers - university students (n = 41), in which we found indicated hearing threshold shift in higher frequencies in 22% of subjects.

The prevalence of audiometric hearing impairment is defined as a threshold average greater than 20 dB hearing level in adults [22], in children it is 16 dB according to Niskar et al. [23]. This threshold exceeded 9 (22 %) subjects in the examinations on frequency 8,000 Hz on the right ear and on the left in 5 (12 %) subjects (Figure 2).

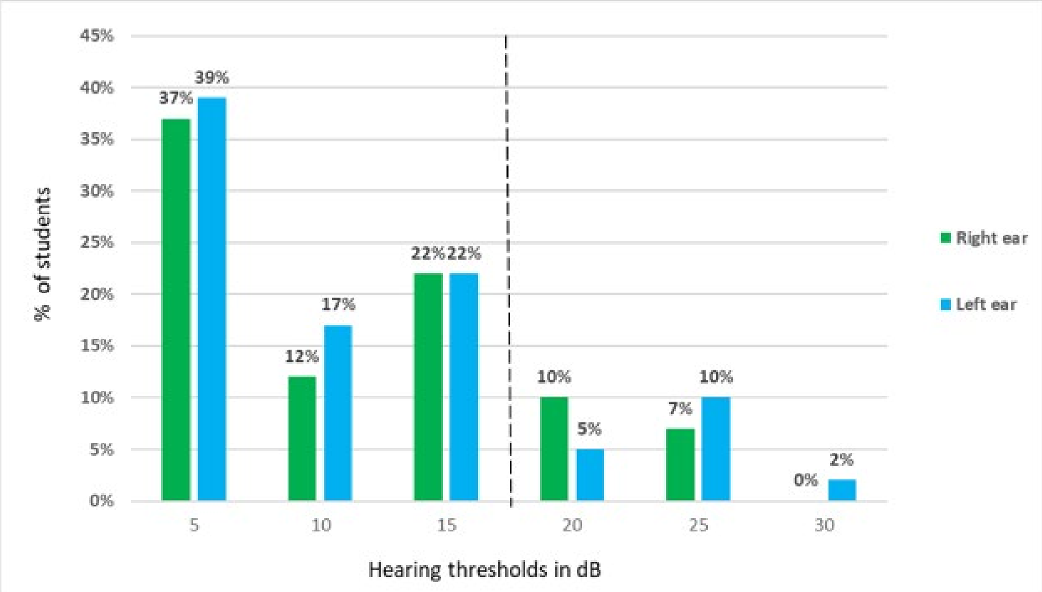

Figure 2. Hearing thresholds for pure tones at 8,000 Hz – right and left ear (n = 41).
Note: On the right side of dotted line – subjects exceeding the threshold (16 dB).

We calculated also hearing threshold averages: low-frequency average (500, 1,000, and 2,000 Hz) on the left and right ear, high-frequency average on the (3,000, 4000, 6,000, and 8,000 Hz) left and right ear. Normal hearing was defined as 0 - 15 dB, slight loss 16-25 dB, mild loss 26-40 dB, moderate loss 41-65 dB and severe loss 66-95 dB. Due to the small group of young healthy volunteers, the results of audiometric tests were only in the first three categories (Table 4, 5).

Our probands had impaired hearing in the higher frequencies of 6,000 Hz and 8,000 Hz bilaterally and also in the lower frequencies of 1,000 Hz in the right ear and 2,000 Hz bilaterally.

Table 4. Prevalence of hearing threshold shifts, Right ear

Frequency, kHz	0-15 dB (Normal)	16-25 dB (Slight)	25 and more dB (Mild)
0,5	100%	0%	0%
1	98%	2%	0%
2	98%	2%	0%
4	100%	0%	0%
6	98%	2%	0%
8	78%	20%	2%

Table 5. Prevalence of hearing threshold shifts, Left ear

Frequency, kHz	0-15 dB (Normal)	16-25 dB (Slight)	25 and more dB (Mild)
0,5	100%	0%	0%

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 November 2019 doi:10.20944/preprints201911.0388.v1

1	100%	0%	0%
2	95%	5%	0%
4	100%	0%	0%
6	93%	7%	0%
8	88%	12%	0%

Of those volunteers who attended audiometric testing, more than 43 % exceeded the LAV (lower action value for industry = 80 dB) by listening to their PMPs. In this group the decreased hearing in 28 % of subjects was found (Figure 5).

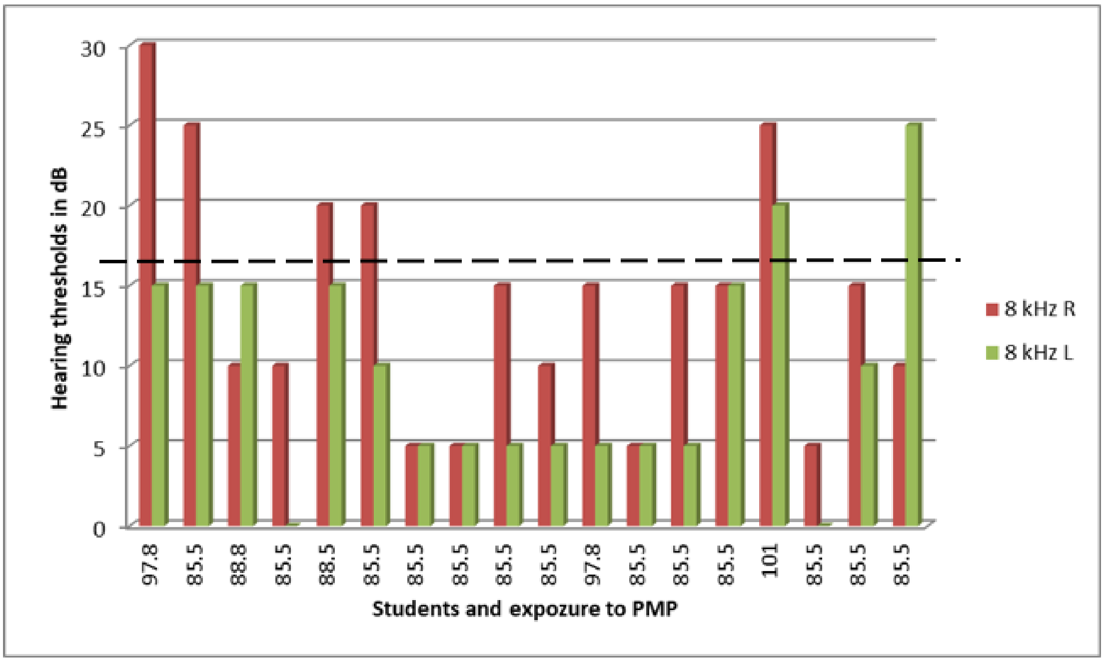

Figure 5. Students listening to PMP on high sound levels and their hearing thresholds at 8 kHz. Note: Above the dotted line – subjects exceeding the threshold (16 dB), R-right ear, L-left ear.

4. Discussion

In our study on 1,003 university students from Bratislava, up to 794 students (79.16 %) reported listening to personal music players (PMP) in the last week, with an average listening time of 285 minutes, 26 % of PMP users exceeded LAV (lower action values of noise at work = 80 dB). In the exposed group 85.59 % of respondents were listening to PMPs compared to the control group, where PMP used 75.76 % of students. This difference was significant on $p < 0.001$. We can conclude that, apart from traffic noise, the probands from the exposed area are also exposed to social noise from personal music players. However, the length and intensity of PMP listening did not differ significantly between these two groups.

On the basis of audiometric tests in a pilot sample of 41 volunteers, we found a threshold shift at high frequencies in 22 % of examined subjects.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 30 November 2019 doi:10.20944/preprints201911.0388.v1

This vulnerable group of young people from the age of 20-30 years is exposed to many noise sources (from traffic, to construction facilities and neighbours, to social noise events with high intensity of noise exposure and in addition to frequent listening to PMP on high volume setting). This group requires a special attention in prevention of hearing impairment. Leisure time activities with high intensity noise exposure are comparable to occupational noise [24]. Various leisure-time activities can be responsible for hearing disorders (temporary or permanent shift of auditory threshold, hearing loss). Exposure to this noise source is compared to the lower noise action value at work. The limit under the Directive 2003/10/EC - noise level A - 80 dB for 40 hours is reached after less than 30 minutes per week [25]. 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. At around 2.5 and 10 million citizens use the PMP so often and so loudly that they risk hearing loss after five years of use [14, 26].

In the most recent studies the authors recommend the use of high-frequency audiometry and evoked otoacoustic emissions (EOAE) (namely transient-evoked otoacoustic emissions (TEOAEs) and distortion-product OAEs (DPOAEs) [15]. OAE (otoacoustic emissions) are the sounds produced by inner ear and recorded by a miniature microphone in the external auditory canal. In the diagnostics only evoked OAE can be used. TEOAE (transient OAE) are emissions (audible responses) from cochlea recorded by a miniature microphone in the probe in an external auditory canal and are caused by small sound impulses (clicks) broadcasted through the probe in an external ear (probe with two channels). DPOAE are generated when the cochlea is stimulated simultaneously by two tones with different frequencies. This frequency specificity allows monitoring of changes in the cochlea and early detection of hearing impairment (noise, ototoxic drugs, morbus Menier). EOAE reflect the integrity of cochlear hair cells and are useful in the pre-clinical detection of hearing impairment. This screening tool is therefore important in the younger individuals [22, 27].

Our results are consistent with the results of other studies, reporting 88-90 % of adolescents and young adults listening to PMP through headphones, especially ear plugs. Recent publications evaluated increased risk of hearing disorders in relation to the listening to PMP and the current incidence of hearing loss and tinnitus. The prevalence of hearing impairment caused by noise in adolescents and young adults was 17 % and 29 % in Europe [7]. Hearing threshold shift ≥ 25 dB at frequencies of one or more occurred in 7.3 % of 177 subjects in Malaysia [28]. In a large sample of students from 9th grade primary schools in Bavaria (n =1,843), the prevalence of audiometric notches was only 2.4 % and indicated the need to follow this sample longitudinally or focus on the older age groups, such as university students [29]. In the study on 34 medical students, regular PMP listeners, the authors observed the immediate effect of short-term PMP listening on DPOAE at 9-12 kHz [30].

Students in our group exposed to traffic noise were listening to PMP more often than students in the control group (maybe trying to mask the noise from traffic or from the other noise sources). However, the volume of listening to PMP was not significantly different between those two groups. In the future we would like to expand the study group to 100 subjects examined by audiometry and to expand the study population to younger categories of teenagers (15 – 19 years old) who start very early with their "noise exposure".

The 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.

5. Conclusions

The results of the study showed the importance of road traffic and the social noise as well. Personal music players are now available to everyone by MP3 players or by smartphones and listening to music through PMPs is extremely popular, especially among young adults. This vulnerable group is additionally exposed to various entertainment and recreational leisure time activities. All these activities may be responsible for an early hearing impairment (temporary or permanent hearing threshold shift, hearing loss) also in younger age groups.

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.

Author Contributions: A.F., L.A. and conceived and designed the project; A.F. and L.A. wrote the manuscript; A.F., K.H., D.V. and L.A. collected and analyzed the data; L.A, J.J., J.B. and B.F. provided critical revision of the manuscript; A.F., M.S., and L.A. performed literature search and drafted sections of the manuscript; A.F., L.A., and J.S. was responsible for funding acquisition and project administration; J.J. and L.A. provided critical revision of the manuscript and did the language, style, and spell check; All authors have approved the submitted version.

Funding: The research was supported by Grant CU / 265/2016 Objectification auditory and non-auditory effects of environmental noise from different sources in a selected population of the vulnerable, Grant CU/195/2017 Objectification of the impact of exposure to different sources of environmental noise by measuring clinical, laboratory and functional parameters in a vulnerable population, Grant CU/132/2015 Analysis of health risks of exposure to environmental noise in the selected vulnerable population and partially by the grant Y.A.B.S. (Youth and Parents Behavioral Survey in Slovakia) O-15-101-/0001-00.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Fritschi, L.; Brown, L.A.; Kim, R.; Schwela, D.; Kephalopoulos, S. Burden of disease from environmental noise. Quantification of healthy life years lost in Europe. Geneva: World Health Organization **2011**, http://www.who.int/quantifying_ehimpacts/publications/e94888.pdf.

2. Argalasova, L.; Jurkovicova, J.; Sevcikova, L.; Stefanikova, Z.; Hirosova, K.; Babjakova, J.; et al. Environmental noise and annoyance in the urban area at different time intervals. Appl Mech Mater **2014**, 617:110-115.

3. Filova, A.; Samohyl, M.; Argalasova, L. Environmental noise exposure and its effect on population health **2015**. Hygiena 60:155-162.

4. Jensen, H.A.R.; Rasmussen, B.; Ekholm, O. Neighbour and traffic noise annoyance: a nationwide study of associated mental health and perceived stress. Eur J Publ Health **2018**, 28(6):1050-1055. https://doi.org/10.1093/eurpub/cky091.

5. Ristovska, G.; Lekaviciute, J. Environmental noise and sleep disturbance: research in Central, Eastern and South-Eastern Europe and Newly Independent States. Noise Health **2013**, 15(62):6-11. https://doi.org/10.4103/1463-1741.107147.
6. Hume, K.I.; Brink, M.; Basner, M. Effects of environmental noise on sleep. Noise Health **2012**, 14(61):297-302. https://doi.org/10.4103/1463-1741.104897.
7. Basner, M.; Brink, M.; Bristow, A.; de Kluizenaar, Y.; Finegold, L.; Hong, J.; et al. ICBEN review of research on the biological effects of noise 2011-2014. Noise Health **2015**, 17 (75):57-82. https://doi.org/0.4103/1463-1741.153373.
8. Basner, M.; McGuire, S. WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep. Int J of Environ Res Publ Health **2018**, 14;15(3). https://doi.org/0.3390/ijerph15030519.
9. World Health Organization; Regional Office for Europe. Environmental Noise Guidelines for the European Region. Copenhagen: WHO **2018**. Available online: http://www.euro.who.int/en/health-topics/environment-and-health/noise/publications/2018/environmental-noise-guidelines-for-the-european-region-2018.

10. Belojevič, G.; Kim, R.; Kephalopoulos, S. Assessment of needs for capacity – building for health risk assessment of environmental noise: case studies. Geneva: World Health Organization **2012**. Available online: http://www.euro.who.int/__data/assets/pdf_file/0007/179116/Assessment-of-needs-for-capacity-building-for-health-risk-assessment-of-environmental-noise,-case-studies-ver-2.pdf.

11. Recio, A.; Linares, C.; Banegas, J.R.; Díaz, J. Road traffic noise effects on cardiovascular, respiratory, and metabolic health: An integrative model of biological mechanisms. Environ Res **2016**, 146:359-70. https://doi.org/10.1016/j.envres.2015.12.036.
12. De Kluizenaar, Y.; Matsui, T. Recent progress in the field of non-auditory health effects of noise-trends and research needs. Proceedings of the 12th ICBEN Congress on Noise as a Public Health Problem **2017**. Zurich, 18 – 22 June 2017. Available online: https://docs.wind-watch.org/ICBEN-2017_de-Kluizenaar_0301_3705.pdf.
13. Argalášova, L.; Filova, A.; Hirosova, K.; Vondrova, D.; Samohyl, M.; Kapsdorfer, D.; et al. The risks of social noise exposure in the vulnerable population in Slovakia. Archives of Acoustics **2016**, 41:535-541
14. SCENIHR. Scientific opinion on the Potential health risks of exposure to noise from personal music players and mobile phones including a music playing function. European Commission, Scientific Committee on Emerging and Newly Identified Health Risks, Brussels, Belgium **2008**. Available online: https://ec.europa.eu/health/ph_risk/committees/04_scenihr/docs/scenihr_o_017.pdf.
15. Keppler, H.; Dhooge, I.; Maes, L.; D'haenens, W.; Bockstael, A.; Philips, B.; Swinnen, F.; Vinck, B. Short-term Auditory Effects of Listening to an MP3 Player. Arch Otolaryngol Head Neck Surg **2010**, 136(6):538-48. https://doi.org/10.1001/archoto.2010.84.
16. Keppler, H.; Dhooge, I.; Maes, L.; Bockstael, A.; Annelies, B.; Philips, B.; Swinnen, F.; Vinck, B. Evaluation of the olivocochlear efferent reflex strength in the susceptibility to temporary hearing deterioration after music exposure in young adults. Noise Health **2014**, 16(69):108-115. https://doi.org/10.4103/1463-1741.132094.

17. Fields, J.M.; De Jong, R.G.; Gjestland, T.; Flindell, I.H.; Job, R.F.S.; Kurra, S.; et al. Standardized general-purpose noise reaction questions for community noise surveys: Research and recommendation. J Sound Vib **2001**, 242 (4):641–679. https://doi.org/10.1006/jsvi.2000.3384.

18. Decree of the Ministry of Health No. 549/2007 Coll. on Permissible Levels of Noise, Infrasound and Vibration and on the Objectification Requirements for Noise, Infrasound d and Vibration in the Environment (Slovak Republic) (in Slovak); **2007**
19. Portnuff, C.D.F.; Fligor, B.J.; Arehart, K.H. Teenage Use of Portable Listening Devices: A Hazard to Hearing? J Am Acad Audiol **2011**, 22:663–677. https://doi.org/10.3766/jaaa.22.10.5.
20. Portnuff, C.D.F.; Fligor, B.J.; Arehart, K.H. Self-report and long-term field measures of MP3 player use: How accurate is self-report? Int J Audiol 2013, 52:33–40. https://doi.org/10.3109/14992027.2012.745649.
21. EUROAKUSTIK: Web page Strategic noise maps **2011**. Available online: http://www.hlukovamapa.sk/index.html.
22. Kabátová, Z.; Profant, M.; Dolezal, P.; Jäger, M.; Pospíšilová, Z.; Profant, O. et al. Audiology. Bratislava: Grada Publishing **2012**.
23. Niscar, A.S.; Kieszak, S.M.; Holmes, A.; Esteban, E.; Rubin, C.; Brody, D.J. Prevalence of hearing loss among children 6 to 19 years of age: the Third National Health and Nutrition Examination Survey. Jama **1988**, 279(14):1071-5.
24. Keppler, H.; Dhooge, I.; Vinck, B. Hearing in young adults. Part I: The effects of attitudes and beliefs toward noise, hearing loss, and hearing protector devices. Noise Health 2015, 17:237-44. https://doi.org/10.4103/1463-1741.165024.

25. 2003/10/EC; Council directive on the minimum health and safety requirements regarding to the exposure of workers to the risks arising from physical factors (noise). European Commission, Brussels, **2003**, 6p.

26. Sliwinska-Kowalska, M.; Zamorowski, K. WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Permanent Hearing Loss and Tinnitus. Int J Environ Res Public Health **2017**, 14:E1139. https://doi.org/10.3390/ijerph14101139.

27. Jakubikova, J. Hearing Loss in Children: Principles and Guidelines for Early Diagnostic, Identification of Etiology and Treatment (in Slovak). Pediatr Prax **2008**, 5:252-256.
28. Sulaiman, A.H.; Seluakumaran, K.; Husain, R. Hearing risk associated with the usage of personal listening devices among urban high school students in Malaysia. Publ Health **2013**, 127:710-715. https://doi.org/10.1016/j.puhe.2013.01.007.
29. Twardella, D.; Perez-Alvarez, C.; Steffens, T.; Bolte, G.; Fromme, H.; Verdugo-Raab, U.; et al. The prevalence of audiometric notches in adolescents in Germany: The Ohrkan-study. Noise Health **2013** 15(67):412-419. https://doi.org/10.4103/1463-1741.121241.
30. Narahari, P.G.; Bhat, J.; Nambi, A.; Arora, A. Impact of usage of personal music systems on oto-acoustic emissions among medical students. Noise Health **2017**, 19(90):222-226 https://doi.org/10.4103/nah.NAH_75_16.