ARCHIVES OF ACOUSTICS
Vol. **42**, No. 1, pp. 113–120 (2017)

DOI: 10.1515/aoa-2017-0012

Hearing Status in Young People Using Portable Audio Players

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(*received March 15, 2016; accepted November 24, 2016*)

The aim of this study was to evaluate the hearing status in young adults using portable audio players (PAPs) in relation to their listening habits.

The study included 58 subjects, aged 22.8±2.8 years, non-occupationally exposed to noise. Questionnaire inquiry aimed at collecting personal data, the information on PAPs usage habits, self-assessment of hearing status and identification of risk factors for noise-induced hearing loss (NIHL) were performed in study subjects. Hearing tests included pure-tone audiometry (PTA) and transient-evoked otoacoustic emission (TEOAE).

All subjects were PAPs users. Depending on listening habits they were divided into the subgroups of "frequent" users (>1 h/day) and "non-frequent" users (≤1 h/day). There were no significant differences between subgroups in prevalence of NIHL risk factors and self-assessment of hearing status. However, frequent users more often complained of tinnitus and hyperacusis.

Majority (81.9%) of participants had normal hearing. Nevertheless, 6.9% of audiograms showed high-frequency notches typical for NIHL. Both, the PTA and TEOAE indicated worse hearing in non-frequent users compared to frequent users. No significant differences in prevalence of high-frequency notches between subgroups were noted.

The outcomes do not support some previous studies results that the excessive exposure to music listened through PAPs might result in accelerating of development of NIHL loss in young adults.

Keywords: Portable Audio Players (PAPs); pure-tone audiometry; transient-evoked otoacoustic emissions (TEOAEs); hearing threshold levels; high-frequency notches; noise-induced hearing loss.

1. Introduction

Noise-induced hearing loss (NIHL) is still a worldwide leading environmental and occupational health risk in industrialized countries and the second most common form of sensorineural hearing impairment, after presbyacusis. However, contrary to occupational exposure, the risk of hearing loss due to environmental exposures to noise or sounds in general population is still not fully recognized.

Among leisure activities accompanied by loud sounds, frequent listening to music through portable audio players (PAPs) seems to be one of the most common sources of high-risk leisure noise, especially for young people.

According to current data approximately 88–90% of young people admit to listening to PAPs (Vogel *et al.*, 2011; Pellegrino *et al.*, 2013). It was also estimated that from 17% to 29% of teenagers and young adults (17% in the USA, 18% in Chile, 22.4% in Canada, 27.4% in Italy, and 28.6% in the Netherlands) are at risk of developing NIHL (Portnuff *et al.*, 2011; 2013; Keith *et al.*, 2011; Muchnik *et al.*, 2012; Breinbauer *et al.*, 2012; Figueiredo *et al.*, 2011; Sulaiman *et al.*, 2013).

Furthermore, the actual hearing loss (≥25 dB HL at one or more standard audiometric frequencies) was observed in 7.3% among 177 young Malaysian PAPs users (Sulaiman *et al.*, 2013). Over 3 times higher prevalence of tinnitus was also found in young Brazilian PAPs users compared to non-users (28% vs. 8%) (Figueiredo *et al.*, 2011). Thus, increasing number of teenagers using portable audio players at high or very high volume settings for several hours a day might result in an increased prevalence of noise-induced hearing loss in the older age of today's young generation.

Therefore, the overall objective of this study was to analyze the hearing status in young adults reporting usage of personal listening devices. In particular, it was attempted to evaluate the prevalence of early signs of NIHL in relation to listening habits.

2. Methodology

The study was carried out in young adults and it involved hearing tests and questionnaire surveys aimed at self-assessment of hearing ability and identification of risk factors for NIHL. Data on habits concerning the usage of PAPs were also collected. The study group comprised 58 volunteers, not exposed to occupational noise, aged from 18.0 to 28.6 years (mean $\pm$ SD: 22.2$\pm$2.8 years). They were recruited through advertisement and received financial compensation for their participation in the study. The study design and methods were approved by the Bioethical Commission of the Nofer Institute of Occupational Medicine, Lodz, Poland.

2.1. Questionnaire surveys

All study subjects filled in a questionnaire to collect information concerning: (i) age and gender, (ii) education and/or profession, (iii) self-assessment of hearing status, (iv) medical history (prior middle-ear diseases,ear surgery, etc.), (v) physical features (body weight, height, skin pigmentation), and (vi) lifestyle (smoking, noisy hobbies, using portable media players, attending disco/bars, rock concerts, etc.). Special attention was paid to PAP-listening behaviours, i.e. frequency (every day, several times a week, occasionally, etc.) and time of daily usage, preferred type of headphones and volume settings. Based on the time of daily usage of PAPs, the subjects were classified into the subgroup of frequent PAPs users (those listening to music through the device for at least 1 hour a day) or to the subgroup of non-frequent PAPs users (those listening to music through the device for less than 1 hour a day).

2.2. Self-assessment of hearing capabilities

All subjects provided information on hearing-related symptoms such as hearing impairment, difficulties in hearing or understanding whisper, normal speech and speech in noisy environment, as well as presence of tinnitus and hyperacusis.

All subjects also completed a (modified) Amsterdam Inventory for Auditory Disability and Handicap ((m)AIADH) (Meijer *et al.*, 2003). This questionnaire consists of 30 questions, including 2 control questions not included in the assessment. The questions are divided into five parts (subscales) assessing separately: (i) the ability of discrimination (differentiation) of sounds (subscale I), (ii) auditory localization (subscale II), (iii) understanding speech in noise (subscale III), (iv) intelligibility in quiet (subscale IV), and (v) detection of sounds (subscale V).

The respondents reported how often they were able to hear effectively in the situations specified above. The four answer categories were as follows: almost never, occasionally, frequently, and almost always. Responses to each question were coded on a scale from 0 to 3; the higher the score, the smaller the perceived hearing difficulties. The total score per subject was obtained by adding the scores for 28 questions. Maximum total score of the questionnaire was 84. Additionally, the answers for each subscale were summed up (maximum score for subscale I was 24, while for the other subscales the total was 15) (Meijer *et al.*, 2003).

2.3. Hearing examination

Standard pure-tone audiometry (PTA) and transient-evoked otoacoustic emission (TEOAE) determinations were made in subjects under study. Before the hearing examinations, otoscopy was performed. Hearing examinations were carried out in a sound-proof room where the A-weighted equivalent-continuous sound pressure level of background noise did not exceed 30 dB.

PTA was performed using an Audio Traveller Audiometer type 222 (Interacoustics) with TDH 39 headphones. Hearing threshold levels (HTLs) for air conduction were determined using an ascending-descending technique in 5-dB steps at the frequencies from 0.25 to 8 kHz. The mean hearing threshold levels in subgroups of subjects were analyzed. The percentage of ears with hearing threshold level exceeding 20 dB at any of high frequencies (>3 kHz) and with mean hearing threshold level exceeding 20 dB HL at speech frequencies (0.5, 1, 2 and 4 kHz) were also calculated in the study subgroups. In order to identify early signs of NIHL the prevalence of high-frequency notches in audiograms was analyzed in the study subgroups. The notch was defined as a sharp drop in the hearing sensitivity at 4000 or 6000 Hz of at least 15 dB in relation to both best preceding threshold occurring at frequencies from 1000 to 3000 (4000) Hz and the threshold at 8000 Hz.

A Scout Otoacoustic Emission System ver. 3.45.00 (Bio-logic System Corp.) was applied for recording and analyzing of otoacoustic emissions. TEOAE recordings of 260 averages each were collected for every subject at stimuli levels of about 80 dB, using standard clicks. The artefact rejection level was set at 20 mPa. Each response was windowed from 3.5 to 16.6 ms post stimulus and band-pass filtered from 0 to 6000 Hz. The total TEOAE amplitude level and the TEOAE amplitude levels for frequency bands with central frequencies 1, 1.5, 2, 3 and 4 kHz were registered.

2.4. Statistical analysis

Answers to the questionnaire and frequency of some outcomes (e.g. prevalence of the high-frequency notched audiograms) were presented as proportions with 95% confidence intervals in the total study group and two subgroups. Differences between subgroups in proportions of answers or outcomes were assessed using chi-square test, while differences in averages of variables (e.g. age, hearing threshold levels) were analyzed using t-test for independent data or Mann-Whitney U-test, where applicable.

The STATISTICA (version 9.1. StatSoft, Inc.) software package was used for statistical analysis. All tests were conducted with assumed significance level $p < 0.05$.

3. Results

3.1. Study subjects characteristic and questionnaire data

The majority (81.0%) of participants were students who were neither occupationally exposed to noise nor to excessive sounds (music) due to frequent playing instruments. However, 25.9% of them were occasionally subjected to noise during internship or apprenticeship (Table 1).

All subjects declared usage of portable audio players. Over half of them used noisy tools (in the past or at the time of the study), about one-quarter practiced noisy motor sports and shooting. A relatively small percentages of participants declared frequent (at least a few times per month) attending music clubs and pubs (6.9%) and loud music concerts (1.7%). Among other risk factors for NIHL, the most frequent was smoking (50%) (Table 1).

Regarding prevalence of other NIHL risk factors, including attending nightclubs, pubs, and music concerts, noisy hobbies, smoking, elevated blood pressure, diabetes, white-finger syndrome, light skin pigmentation, ototoxic antibiotic treatments and overweight

Table 1. Study groups characteristics. Data concern all subjects and two subgroups of subjects which were taken for further analysis.

	Total	Frequent users of PAPs	Non-frequent users of PAPs
Number of subjects	58	35 (60.3%)	23 (39.7%)
Females	29 (50.0%)	17 (48.6%)	12 (52.2%)
Males	29 (50.0%)	17 (51.4%)	11 (47.8%)
Students	47 (81.0%)	28 (80.0%)	19 (82.6%)
Age: mean ± SD [years]	22.2±2.8	22.1±2.9	22.5±2.8
Prevalence of risk factors for NIHL	Proportion (95%CI) [%]		
Occasional (occupational) exposure to noise	25.9 (16.3–38.5)	22.9 (11.9–39.3)	30.4 (15.6–51.1)
Listening to PAPs	100.0 (92.6–100.0)	100.0 (88.2–100.0)	100.0 (83.1–100.0)
Frequent attending to clubs, pubs, etc.	6.9 (2.3–17.0)	8.6 (2.3–23.3)	4.3 (0.0–22.7)
Frequent attendance loud music concerts, etc.	1.7 (0.0–10.0)	0.0. (0.0 –11.8)	4.3 (0.0–22.7)
Practice noisy motor sports	24.1 (14.9–36.7)	22.9 (11.9–39.3)	26.1 (12.4–46.9)
Shooting	29.3 (19.2–42.1)	34.3 (20.8–51.0)	21.7 (9.4–42.5)
Usage of noisy tools	56.9 (44.1–68.8)	57.1 (40.8–72.0)	56.5 (36.8–74.3)
Smoking	50.0 (37.6–62.4)	51.4 (35.6–67.0)	47.8 (29.3–67.0)
Elevated blood pressure	6.9 (2.3–17.0)	5.7 (0.7–19.8)	8.7 (1.4–28.2)
Diabetes	0.0 (0.0–7.4)	0.0. (0.0 –11.8)	0.0 (0.0–16.9)
Raynaud's phenomenon	3.4 (0.3–12.6)	5.7 (0.7–19.8)	0.0 (0.0–16.9)
Light skin pigmentation	20.7 (12.2–33.0)	25.7 (14.1–42.3)	13.0 (3.9–33.2)
Ototoxic antibiotic treatment	8.6 (3.4–19.2)	8.6 (2.3–23.3)	8.7 (1.4–28.2)
BMI >25	29.3 (19.2–42.1)	31.4 (18.5–48.1)	26.1 (12.4–46.9)

95% CI – 95% confidence interval; NIHL – noise induced hearing loss; PAPs – personal listening devices; BMI – body mass index.

(BMI >25), there were no significant differences between frequent and non-frequent PAPs users.

Taking into consideration the PAP usage behaviours, 60.3% of subjects listened over 1 h/day and 71.4% set volume at over 50% of the maximum value (Fig. 1). Furthermore, PAPs were used 5.4±1.8 times a week on average. The subjects' classified as frequent users listened to music through the PAPs more times a week compared to non-frequent users (6.0±1.5 vs. 4.5±1.9, $p < 0.05$; median values 7 and 3, respectively) and more often listened at maximum volume setting (Figs. 1 and 2).

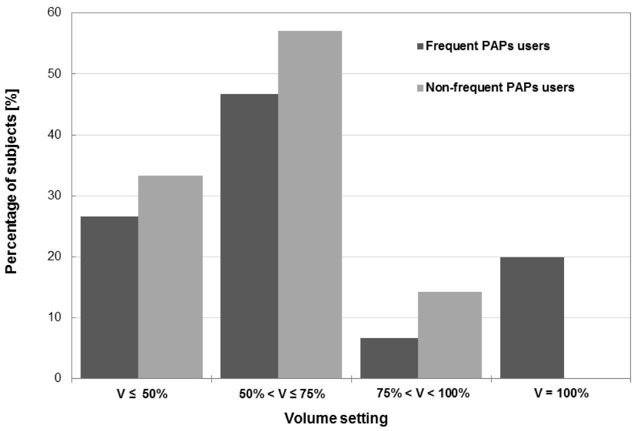

Fig. 1. Listening behaviours in frequent and non-frequent users of PAPs – volume settings.

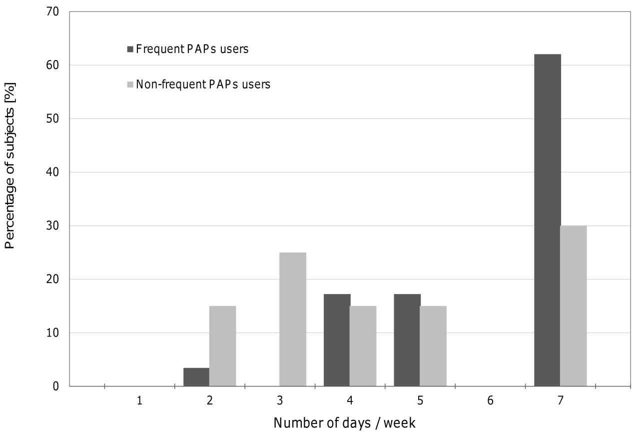

Fig. 2. Listening behaviours in frequent and non-frequent users of PAPs – number of days per week using PAPs.

3.2. Self-assessment of hearing capability

Almost all participants (98.3%) assessed their hearing as good. Nevertheless, some of them complained of various hearing-related symptoms (Table 2). In particular, some of them reported hearing impairment (15.5%) and complained of difficulty in hearing whisper (25.9%), problems with understanding speech in noisy environment (34.5%), having hyperacusis (6.9%) and tinnitus (5.2%) (Table 2).

Frequent PAPs users more frequently complained of tinnitus and hyperacousis in comparison to non-frequent users while the opposite relation were observed when analyzing self-reported hearing impairment as well as difficulties in hearing whisper and understanding speech in noisy environment. But these differences were not significant (Table 2).

Table 3 presents subjects' self–assessment of hearing ability in terms of the (m)AIADH. The mean total score was 87.6% of maximum value (84) which suggests no substantial hearing problems (Table 3). Only a few of subjects (5.2%, 95% CI: 1.3–14.8%) obtained the total score under 70% of the maximum value. Relatively low scores were more frequent in subscales evaluating auditory localization (subscales II) and intelligibility in noise (subscale III), since 15.5% (95% CI: 8.2–27.3%) and 10.3% (95%CI: 4.6–21.2%) of subjects scored below 70% of maximum value. However, neither significant differences in the total score nor in the scores in various subscales were noted between the frequent and non-frequent users of PAPs (Table 3).

Table 2. Incidence of self-reported hearing-related symptoms in study subjects.

	Total	Frequent users of PAPs	Non-frequent users of PAPs
	Proportion (95%CI) [%]		
Good hearing	98.3 (90.0–100.0)	100.0 (88.2–100.0)	95.7 (77.3–100)
Hearing impairment			
self–reported	15.5 (8.2–27.3)	11.4 (4.1–26.7)	21.7 (9.4–42.5)
noticed by family	10.3 (4.6–21.2)	8.6 (2.3–23.3)	13.0 (3.9–33.2)
Difficulties with hearing/understanding			
whisper	25.9 (16.3–38.5)	17.1 (7.8–33.2)	39.1 (22.2–59.3)
normal speech	1,7 (0.0–10.0)	2.9 (0.0–15.8)	0.0 (0–16.9)
speech in noisy environment	34.5 (23.6–47.4)	25.7 (14.1–42.3)	47.8 (29.3–67.0)
Tinnitus	5.2 (1.3–14.8)	8.6 (2.3–23.3)	0.0 (0.0–16.9)
Hyperacusis	6.9 (2.3–17.0)	11.4 (4.1–26.7)	0.0 (0.0–16.9)

95% CI – 95% confidence interval; PAPs – personal listening devices.

Table 3. Hearing ability in terms of score in the (modified) Amsterdam Inventory for Auditory Disability and Handicap in study subjects.

Score in the (m)AIADH	Total	Frequent users of PAPs	Non-frequent users of PAPs
	Mean ± SD		
Total	73.6±7.7	73.8±7.9	73.3±7.5
Subscale I (distinction of sounds)	21.9±2.5	21.9±2.8	21.9±2.0
Subscale II (auditory localization)	12.8±2.2	12.8±2.1	12.7±2.3
Subscale III (intelligibility in noise)	12.2±1.3	12.2±1.4	12.2±1.1
Subscale IV (intelligibility in quiet)	13.4±1.3	13.5±1.3	13.2±1.3
Subscale V (detection of sounds)	13.3±2.0	13.4±2.0	13.3±2.1

(m)AIAHD – (modified) Amsterdam Inventory for Auditory Disability and Handicap; SD – standard deviation.

3.3. Results of hearing tests

Audiometric hearing threshold levels (HTLs) determined in study subjects are shown in Fig. 3. Generally, the majority (81.9%) of them had HTLs (in the frequency range 1–8 kHz) within normal limits (≤20 dB HL). The percent of subjects with mean HTL at speech frequencies (0.5, 1, 2 and 4 kHz) exceeding 20 dB HL was higher in non-frequent users than frequent users (6.5 vs. 0.0%, $p < 0.05$). The percent of ears with HTL exceeding 20 dB HL in any of high frequencies (3–8 kHz) was also higher in the subgroup of non-frequent PAPs users (21.7%) compared to frequent users (10.0%) (Table 4). However, the difference was not statistically significant.

Typical NIHL notches at 4000 or 6000 Hz of at least 15 dB depth were observed in 6.9% (Table 4). Majority of them (87.5%) occurred at frequency of 6000 Hz. No bilateral notching at any frequency was noted. There were no statistically significant differences in prevalence of notches between subgroups of subjects, although they appear to be more frequent in non-frequent users of PAPs. Furthermore, the latter subjects had significantly higher (worse) HTLs (at 1000 and 6000 Hz) as compared to frequent PAPs users (Fig. 3).

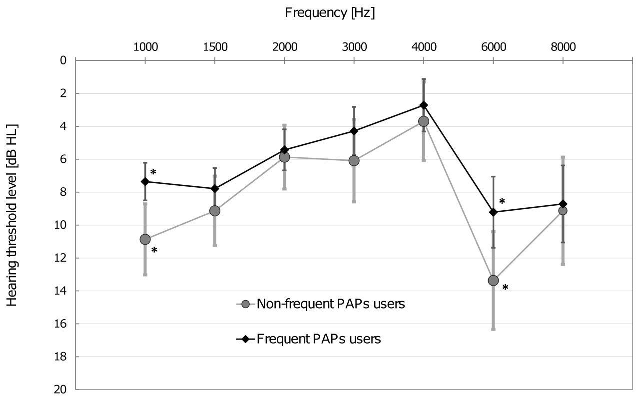

Fig. 3. Audiometric hearing threshold levels (mean ± 95% confidence interval) in frequent and no-frequent PAPs. Significant differences between subgroups were marked by (*).

Table 4. Summary results of pure-tone audiometry in study subjects.

Pure tone audiometry results	Total	Frequent users of PAPs	Non-frequent users of PAPs
	Proportion of audiograms (95% CI) [%]		
Mean hearing threshold level			
at frequencies of 0.5, 1, 2 and 4 kHz > 20 dB HL	2.6 (0.6–7.7)	0.0 (0.0–6.2)*	6.5 (1.7–18.3)*
in frequency range 3–8 kHz > 20 dB HL	3.4 (1.1–8.9)	2.9 (0.3–10.6)	4.3 (0.5–15.5)
Any hearing threshold level			
at frequencies of 0.5, 1, 2 and 4 kHz > 20 dB HL	6.9 (3.4–13.3)	2.9 (0.3–10.6)*	13.0 (5.8–26.2)*
in frequency range 3–8 kHz > 20 dB HL	14.7 (9.3–22.4)	10.0 (4.7–19.6)	21.7 (12.2–35.8)
High-frequency notch			
total	6.9 (3.4–13.3)	5.7 (1.9–14.3)	8.7 (3.0–21.0)
right ear	3.4 (0.3–12.6)	2.9 (0.0–15.8)	4.3 (0.0–22.7)
left ear	10.3 (4.6–21.2)	8.6 (2.3–23.3)	13.0 (3.9–33.2)
bilateral notch	0.0 (0.0–7.4)	0.0 (0.0 –11.8)	0.0 (0.0 –16.9)

95% CI – 95% confidence interval; * Significant differences between subgroups ($p < 0.05$).

Results of TEOAE testing are summarized in Fig. 4 and 5. Generally, in all analyzed ears the reproducibility of total response was greater than 60% and signal to noise ratio (SNR) exceeded 6 dB. Furthermore, similarly to audiometry, TEOAE indicated worse hearing in non-frequent compared to frequent users of PAPs. The non-frequent users had lower SNR (both for the whole response and for frequency bands of 1.5–4 kHz) and smaller reproducibility (both for the whole response and for all frequency bands of 1.0–4 kHz, excluding 3 kHz) (Fig. 4). However, these differences were not significant.

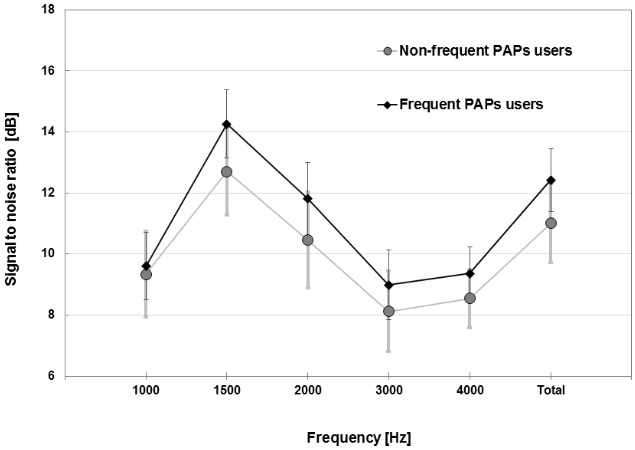

Fig. 4. TEOAEs (mean ± 95% confidence interval) in frequent and non-frequent PAPs users – signal to noise ratio. No significant differences were observed between subgroups of subjects.

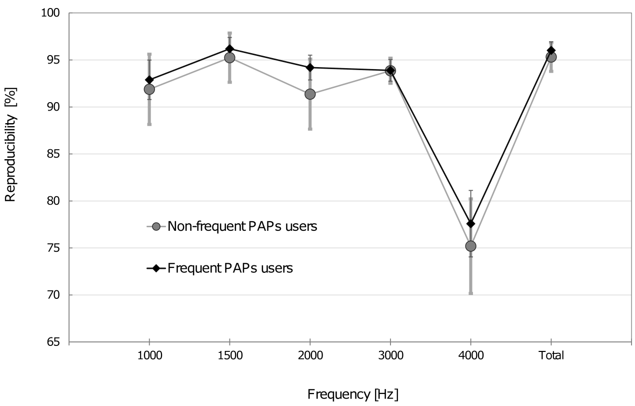

Fig. 5. TEOAEs (mean ± 95% confidence interval) in frequent and non-frequent PAPs users – reproducibility of response. No significant differences were observed between subgroups of subjects.

4. Disscusion

The overall objective of this study was to analyze the possible impact of frequent usage of portable audio players on hearing ability in young adults. It was designed as the initial preparatory stage to the relevant cross-sectional study aimed at evaluation of the prevalence and risk of noise-induced hearing loss due to frequent listening to PAPs in young Polish population. Therefore, this study was limited to hearing tests and questionnaire surveys in young volunteers. Neither portable audio players' output capabilities nor volunteers' preferred output levels were evaluated based on sound pressure level measurements.

However, earlier Rogowski *et al.* (2001) investigated the preferred levels of music reproduction from the portable audio players in 284 pupils of Warsaw secondary schools. They measured sound pressure level (SPL) under headphones attached to the IEC 711 standard acoustic coupler (connected to sound level meter) and found that the average user of a portable player was exposed to the A-weighted equivalent-continuous sound pressure level of 103 dB, while instantaneous SPL reached 117 dB for 1% of the duration of exposure.

It is worth underlining that in order to compensate for the acoustical effects of the head and pinna and to allow comparisons to the applicable regulatory limits, measured levels should be either corrected using a single number of 8 to 10 dB or through a frequency-dependent equalization network (Nassrallah *et al.*, 2013). Such corrections were not applied in the aforesaid study. However, even when subtracting a 10 dB correction factor, the resultant sound pressure level exceeded 90 dBA, indicating that young users of portable audio players were exposed to sounds at levels that might cause hearing loss.

In this study, all participants declared usage of PAPs. However, only 60.3% of them listened over 1 hour per day. Furthermore, those subjects more often used PAPs and set volume at maximum value. Thus, those subjects who declared using over 1h/day were classified as frequent PAPs users, while the others were classified as non-frequent users.

It is known that individual susceptibility (or vulnerability) to noise, along with the degree of hearing loss, varies greatly among people. It is believed that NIHL is a complex disease resulting from the interaction between intrinsic and environmental factors. Besides well-known environmental factors contributing to NIHL, such as exposure to occupational and non-occupational noise, some others may also play a role, including smoking, elevated blood pressure, diabetes, cholesterol levels, skin pigmentation (Sliwinska-Kowalska *et al.*, 2006).

Regarding other noisy or loud activities, a relatively small percentage of participants declared frequent (at least a few times per month) attending music clubs and pubs (6.9%) and loud music concerts (1.7%). On the other hand, over half of them used (at the time of the study or in the past) noisy tools, while over one-quarter practiced noisy motor sports or shooting and were occasionally exposed to occupational noise.

Additional NHIL risk factors, excluding smoking, were rather rare in the study. It is worth underlining that a half of subjects reported smoking at the time of the study or in the past. Furthermore, they were (or have been) smokers up to 10 years (about 2 years on average). But besides PAP-listening habits, there were no significant differences in the aforesaid NIHL risk factors between frequent and non-frequent PAPs users.

Generally, the majority of study subjects had audiometric hearing levels within normal limits ($\leq$20 dB HL). Thus, to identify early signs of NIHL the prevalence of high-frequency notches (i.e. a sharp drop in the hearing sensitivity at 4000 or 6000 Hz) in audiograms were analyzed. It was found that typical high-frequency notches (mainly at 6000 Hz) were observed in 6.9% of analyzed audiograms.

NIHL develops very slowly over the years of exposure. Thus, the effects of overexposure to loud music could be difficult to single out in teenagers with relatively short duration of PAPs usage. For example, according to the ISO 1999 (2013) model, a shift of hearing threshold greater or equal to 25 dB in speech frequencies should not take place in males with healthy ears, provided the exposure to noise does not exceed 15 years for 85 dBA level and 6 years for 90 dBA level (ISO 1999, 2013). Thus, it is not surprising that in this study the proportion of NIHL notches in audiograms did not differ significantly between frequent and non-frequent PAPs users. However, significant differences in the prevalence of hearing impairment in speech and high frequency ranges between these subgroups were observed. But contrary to our expectations non-frequent users had worse HTLs than frequent users of PAPs. The explanation for this finding could be that non-frequent users attended more frequently loud music concerts.

The literature concerning recreational exposures to loud sounds, including listening to music through PAPs, is quite extensive. However, the data on exposure-response relationship between the exposure to music listened to through PAPs and permanent hearing loss measured by quantifiable hearing test are very scarce.

According to the Malaysian and Canadian studies exposures to loud music listened to through PAPs may result in hearing threshold shifts, provided the level of music is high and the duration of exposure is long (more than 5 years). The results of these studies show that if the exposure to music is relatively short (mean 3.2 years), typical signs of NIHL are not detected in the standard audiometric frequencies (0.25–8 kHz) but can be visible at extended high frequencies (Sulaiman *et al.*, 2013). As anticipated, the early stages of NIHL can also be recognized by decreasing the signals of otoacoustic emissions (Sulaiman *et al.*, 2014). Similar decrease in TEOAE was found in our study. Furthermore, using PAPs for a longer time was shown to be associated with increased incidence of permanent hearing loss and worsening of hearing thresholds at standard test frequencies related to the exposure level (Feder *et al.*, 2013; Sulaiman *et al.*, 2014).

Unfortunately, in our study the duration (in years) of the PAPs usage was not analyzed. However, besides pure tone audiometry, the TEOAEs determinations were conducted in participants. In all analysed ears the reproducibility of total response was greater than 60% and signal to noise ratio (SNR) exceeded 6 dB. TEOAE indicated better hearing in frequent compared to non-frequent users of PAPs which was in accordance with the results of pure-tone audiometry.

5. Conclusion

Although data presented here did not support the thesis that frequent usage of PAPs was associated with higher risk of worsening hearing ability in young adults, further studies are needed.

Acknowledgments

This study was supported by the Ministry of Science and Higher Education of Poland (Grant IMP 18.2/2012-2013).

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