

Risk of Damage to Hearing from Personal Listening Devices in Young Adults

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ABSTRACT

Objective: To investigate the effects of personal listening device use on hearing in young listeners.

Methods: Conventional frequency audiometry (0.5–8 kHz) and extended high-frequency audiometry (10–20 kHz) were performed on 120 personal listening device users and 30 normal-hearing young adults.

Results: The hearing thresholds in the 3 to 8 kHz frequency range were significantly increased in the personal listening device listeners. The frequency range of the increased thresholds became broad as the exposure duration was increased. Impaired hearing was detected in 14.1% (34 of 240 ears) of ears (> 25 dB HL in one or more frequencies in 0.5–8 kHz). The hearing thresholds of extended high-frequency audiometry in personal listening device users could also be increased even if their hearing thresholds in conventional frequency audiometry were normal.

Conclusion: Our results suggest that long-term use of personal listening devices can impair hearing function. The data also indicate that extended high-frequency audiometry is a sensitive method for early detection of noise-induced hearing loss.

SOMMAIRE

Objectif: Investiguer les effets du baladeur sur l'audition des jeunes.

Méthodes: Par audiométrie conventionnelle (0.5–8 kHz) et de hautes fréquences (10–20 kHz), nous avons mesuré l'audition de 120 utilisateurs de baladeur et 30 jeunes adultes normaux.

Résultats: Les seuils d'audition entre 3 et 8 kHz étaient significativement élevés chez les utilisateurs de baladeur. L'étendue des fréquences affectées s'élargit quand la durée d'exposition augmente. L'audition de 14.1% (34 sur 240) des oreilles était affectée (> 25 dB HL dans au moins une fréquence entre 0.5 et 8 kHz). Le seuil des fréquences plus élevées pouvait aussi être affecté même si les fréquences conventionnelles étaient normales.

Conclusion: Nos résultats suggèrent que l'utilisation à long terme de baladeurs peut affecter l'audition. Ces données indiquent aussi que l'audiométrie étendue aux hautes fréquences est une méthode sensible pour la détection précoce de la surdité induite par le bruit.

Key words: conventional frequency audiometry, extended high-frequency audiometry, noise-induced hearing loss, personal listening devices

It is well known that exposure to occupational noise can induce noise-induced hearing loss (NIHL). Recently, attention has turned to nonoccupational or recreational noise that can also induce hearing loss. Although there are many possible sources of potentially

hazardous leisure noise, much attention has focused on the effects of personal listening devices (PLDs), such as a Walkman cassette player, a CD player, and an MP3 player.

Recent years have seen an increase in the use of PLDs, and many studies have raised concern over their effects on hearing. It has been shown in many reports that the use of a PLD has damaging effects on hearing. Wood and colleagues and Katz and colleagues reported that the maximum available sound pressure levels from a stereo headphone were 124 and 128 dBA, respectively.^{1,2} Fligor and Cox reported that free-field equivalent sound pressure levels measured at a maximum volume control setting ranged from 91 to 121 dBA and insert earphones increased output level from 7 to 9 dB.³ They concluded that the use of the PLDs would have a risk of damaging hearing.

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Turunen-Rise and colleagues found that 6 of 10 subjects displayed a temporary threshold shift after 1 hour's use of a PLD.⁴ Lee and colleagues also found that 40% of subjects demonstrated 10 dB hearing loss at 4 or 6 kHz.⁵ The hearing loss was associated with exposure to leisure noise. Recently, the results of an interdisciplinary long-term study showed that the equivalent sound levels in discos ranged from between 104.3 and 112.4 dBA and between 75 and 105 dBA from personal music players.⁶ Exposure to high sound levels during leisure activities can cause permanent hearing damage among young people.⁷ However, contrary reports indicating that the use of PLDs had no damaging effects on the hearing of users have also been published.⁸⁻¹⁰

It has been found that the early acoustic trauma in cochlea appeared in the extended high-frequency range (10–20 kHz).¹¹ Extended high-frequency audiometry can sensitively detect the risk of damage from noise exposure early. The main purposes of this study were to investigate the effects of PLDs on the hearing of young listeners and whether extended high-frequency audiometry is more sensitive than conventional frequency audiometry in early detection of NIHL.

Subjects and Methods

Subjects

The subjects of the PLD group were students at Wuhan University who responded to an advertisement for volunteers who used PLDs at least 1 hour or more per day. The PLD group included 120 young adults (64 males and 56 females; age range 19–23 years, mean 20.6 years). Exclusion criteria included exposure to loud noise within 24 hours of examination, a history of chronic ear disease, use of an ototoxicity drug, diagnosed hearing impairment, current upper respiratory infection, and evidence of

middle ear dysfunction after tympanometry. The PLD group was divided into three subgroups according to the duration of use: 1 to 3 years, 3 to 5 years, and > 5 years. All subjects completed a questionnaire regarding their history of noise exposure including source(s) of exposure and sound level (low, medium, or high) before audiometry. The control group was composed of 30 normal-hearing young adults who had no history of use of a PLD (16 males and 14 females; age range 19–22 years, mean 20.5 years). All of them had normal hearing in the range of 0.5 to 8 kHz (< 25 dB HL). In our study, we required that all subjects in the PLD group had to avoid the use of devices for 24 hours before the tests.

Instrumentation and Procedure

The measurements were performed in a sound-proofed room in which the noise floor was below 25 dBA. Following an otoscopic examination, screening tympanography was performed bilaterally. Conventional frequency audiometry was performed with a TDH-39 earphone using a DA-64 clinical audiometer (Danplex, Denmark) on each subject at the following frequencies: 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz. Extended high-frequency audiometry was performed with a Sennheiser HAD-200 earphone (Wedemark, German) using an Orbiter-922 clinical audiometer (Madsen, Denmark) at the following frequencies: 10, 12.5, 16, and 20 kHz.

Analyses of variance and χ^2 test were performed using SPSS (version 13.0) software (SPSS Inc, Chicago, IL). The level of significance was set at $p < .05$.

Results

Significant differences were found between the control group and the three PLD subgroups in the hearing thresholds of conventional frequencies ($p < .01$; Table 1). In the

Table 1. Results of Conventional Frequency Hearing Thresholds (dB HL, mean \pm Standard Deviation)

Frequency (kHz)	Control	1–3 yr	3–5 yr	> 5 yr
0.5	6.75 \pm 3.55	8.55 \pm 3.99	8.27 \pm 3.86	8.24 \pm 3.09
1.0	4.75 \pm 3.49	6.29 \pm 4.61	5.82 \pm 3.42	7.43 \pm 4.09**
2.0	7.50 \pm 4.76	7.90 \pm 4.10	8.50 \pm 4.37	10.59 \pm 5.08**
3.0	5.17 \pm 4.51	7.42 \pm 4.77*	7.64 \pm 6.42*	7.96 \pm 5.88*
4.0	5.25 \pm 4.91	8.63 \pm 8.06*	8.32 \pm 9.68*	11.12 \pm 12.45**
6.0	5.08 \pm 3.74	12.42 \pm 11.58**	10.14 \pm 11.70**	11.47 \pm 14.68**
8.0	8.25 \pm 5.03	19.60 \pm 11.32**	16.59 \pm 13.04**	17.57 \pm 13.25**

* $p < .05$ compared with control group.

** $p < .01$ compared with control group.

5-year subgroup, the frequency of threshold shifting was broad, from 1.0 to 8.0 kHz. The hearing thresholds of the three PLD subgroups in the extended high-frequency range were also significantly higher than those of the control group in all tested frequencies ($p < .01$; Table 2). However, there was no significant difference among the three PLD subgroups ($p > .05$; see Table 2).

According to the hearing thresholds in the range of 0.5 to 8 kHz, the PLD group could be divided into two subgroups, the normal-hearing subgroup and the hearing-impaired subgroup. The subjects with normal hearing thresholds in the range of 0.5 to 8 kHz (< 25 dB HL) were classified as the normal-hearing subgroup. Those with abnormal hearing thresholds in one or more frequencies in the range of 0.5 to 8 kHz (> 25 dB HL) were classified as the hearing-impaired subgroup. There were 206 ears in the normal-hearing group and 34 ears in the hearing-impaired group according to this criterion. Table 3 shows that the extended high-frequency hearing thresholds of the normal-hearing subgroup were significantly higher than those of the control group at 10, 12.5, and 16 kHz, although they had normal hearing thresholds in the range of 0.5 to 8 kHz. The extended high-frequency hearing thresholds of hearing-impaired subgroup subjects were significantly higher than those of the control group and the normal-hearing subgroup (see Table 3).

The detection rates of extended high-frequency hearing thresholds are shown in Table 4. There were significant differences between the control group and the normal-hearing subgroup at 20 kHz. The detection rates in the hearing-impaired subgroup were significantly lower than those in the control group and the normal-hearing subgroup at 16 and 20 kHz (see Table 4).

Discussion

The present study investigated the prevalence and magnitude of NIHL in young adults to understand the risk of hearing damage from PLDs. All subjects in our study were selected on the basis of substantial exposure to use of PLDs. Our study showed that the hearing loss occurred in 14.1% (34 of 240) of ears following long-term use of PLDs.

Clearly, the maximum available sound pressure levels from a stereo headphone can produce sound levels in excess of 100 dBA,^{1,2} which is much higher than the preferred volume setting of most users. Williams reported that the average, A-weighted, 8-hour equivalent, continuous noise exposure level of the preferred volume setting was determined to be 79.8 dBA.⁸ This noise level does not exceed the safety standards of the Occupational Safety and Health Administration (OSHA), which allows for unprotected exposure up to 90 dBA for 8 hours per day. However, we found that this noise level could still induce

Table 2. Results of Extended High-Frequency Hearing Thresholds (dB SPL, mean \pm Standard Deviation)

Frequency (kHz)	Control	1-3 yr	3-5 yr	> 5 yr
10	13.33 \pm 4.86	20.97 \pm 11.02**	19.05 \pm 13.80**	19.41 \pm 13.86**
12.5	26.08 \pm 8.54	36.53 \pm 18.14**	38.45 \pm 17.98**	35.59 \pm 18.08**
16	48.50 \pm 9.64	62.05 \pm 21.39**	63.09 \pm 23.00**	63.76 \pm 18.08**
20	89.37 \pm 7.68	96.86 \pm 6.33**	96.95 \pm 7.59**	97.44 \pm 6.59*

* $p < .05$ compared with control group.

** $p < .01$ compared with control group.

Table 3. Results of Extended High-Frequency Hearing Thresholds (dB SPL, mean \pm Standard Deviation)

Frequency (kHz)	Control	Normal Hearing	Hearing Impaired
10	13.25 \pm 4.86	15.66 \pm 6.44**	42.06 \pm 19.11***††
12.5	25.75 \pm 8.92	33.03 \pm 13.88**	61.47 \pm 22.16***††
16	48.50 \pm 17.64	56.05 \pm 20.54*	82.99 \pm 19.24***††
20	89.92 \pm 7.67	94.10 \pm 7.23	97.79 \pm 4.95***††

* $p < .05$ compared with control group.

** $p < .01$ compared with control group.

†† $p < .01$ compared with normal-hearing group.

Table 4. Detection Rates of Extended High-Frequency Hearing Thresholds

Frequency (kHz)	Control		Normal Hearing		Hearing Impaired	
	n	Rate (%)	n	Rate (%)	n	Rate (%)
10	60	100.0	206	100.0	34	100.0
12.5	60	100.0	206	100.0	32	94.1
16	60	100.0	201	97.6	28	82.5***††
20	54	90.0	118	57.3**	15	44.1***††

** $p < .01$ compared with control group.

†† $p < .01$ compared with normal-hearing group.

hearing loss (NIHL occurred in 14.1% of ears). The possible explanations are as follows: first, the spectrum of amplified music differs from that of industrial noise, to which federal workplace noise standards are applicable.^{3,12} For example, the spectrum of amplified music emphasizes low frequencies compared with the relatively flat spectra typical of industrial noise.¹³ Second, industrial noise is a relative steady noise, whereas amplified music is a nonsteady noise, which can induce more severe damage than steady noise.¹⁴ Third, the preferred volume setting is usually set according to the typical type of music (popular music) in a typical moment. Thus, the actual intensity for other types of music, such as rock, may be higher.

The duration of noise exposure is another important factor for NIHL. We found that hearing threshold shift occurred in a broad frequency range and had a high incidence of hearing damage in the 5 years subgroup. This revealed that the risk of damage to hearing is increased as the duration of noise exposure lasts longer.

In this study, we used extended high-frequency audiometry to evaluate the risk of damage of PLDs to hearing. We found that extended high-frequency audiometry is a sensitive method and can detect damages in hearing function early. To our knowledge, extended high-frequency audiometry can demonstrate extended high frequency hearing (8–20 kHz) at the base of the cochlea and can provide information that conventional frequency audiometry cannot provide.¹¹ We found that the hearing thresholds of the hearing-impaired subgroup were significantly higher than those of the control group in the range of 10 to 20 kHz. The extended high-frequency hearing thresholds were significantly higher than those of the control group (see Table 3) in the normal-hearing subgroup, although they had completely normal hearing thresholds at 0.5 to 8 kHz. Moreover, we found no significant differences between the control group and the normal-hearing subgroup in hearing threshold at 20 kHz

(see Table 3); the detection rates of the normal-hearing subgroup were significantly lower than those of the control group at 20 kHz (see Table 4). Thus, extended high-frequency audiometry is more sensitive than conventional frequency audiometry in early detection of NIHL.

Conclusion

The results demonstrate that the long-term use of PLDs can induce NIHL. Hearing impairment occurred in 14.1% of ears (34 of 240 ears). Extended high-frequency audiometry is a sensitive method for early detection of NIHL. Finally, we suggest that users of PLDs should sensibly control their listening duration and intensity to avoid developing NIHL.

References

1. Wood WS, Lipscomb DM. Maximum available sound-pressure levels from stereo components. *J Acoust Soc Am* 1972;52:484–7.
2. Katz AE, Gerstman HL, Sanderson RG, et al. Stereo earphones and hearing loss. *N Engl J Med* 1982;307:1460–1.
3. Fligor BJ, Cox LC. Output levels of commercially available portable compact disc players and the potential risk to hearing. *Ear Hear* 2004;25:513–7.
4. Turunen-Rise I, Flottorp G, Tveten O. Personal cassette players (Walkman). Do they cause noise-induced hearing loss? *Scand Audiol* 1991;20:239–44.
5. Lee RE, Roberts JH, Wald Z. Noise induced hearing loss and leisure activities of young people: a pilot study. *Can J Public Health* 1985;76:171–3.
6. Serra MR, Biassoni EC, Richter U. Recreational noise exposure and its effects on the hearing of adolescents. Part I: an interdisciplinary long-term study. *Int J Audiol* 2005;44:65–73.
7. Biassoni EC, Serra MR, Richter U. Recreational noise exposure and its effects on the hearing of adolescents. Part II: development of hearing disorders. *Int J Audiol* 2005;44:74–85.
8. Williams W. Noise exposure levels from personal stereo use. *Int J Audiol* 2005;44:231–6.
9. Bradley R, Fortuna H, Coles R. Patterns of exposure of school children to amplified music. *Br J Audiol* 1987;21:119–25.

10. Mostafapour SP, Lahargoue K, Gates GA. Noise-induced hearing loss in young adults: the role of personal listening devices and other sources of leisure noise. *Laryngoscope* 1998;108:1832-9.
11. Fausti SA, Erickson DA, Frey RH, et al. The effects of noise upon human hearing sensitivity from 8000 to 20000 Hz. *J Acoust Soc Am* 1981;69:1343-7.
12. Hetu R, Fortin M. Potential risk of hearing damage associated with exposure to highly amplified music. *J Am Acad Audiol* 1995;6:378-86.
13. Burns W, Robinson DW. An investigation of the effects of occupational noise on hearing. *Ciba Found Symp* 1970;177-92.
14. Mantysalo S, Vuori J. Effects of impulse noise and continuous steady state noise on hearing. *Br J Ind Med* 1984;41:122-32.

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