

Hearing Deficits in Young Adults Who Had a History of Otitis Media in Childhood: Use of Personal Stereos Had No Effect on Hearing

Brechtje A. de Beer, MD*‡; Kees Graamans, MD, PhD*; Ad F. M. Snik, PhD*; Koen Ingels, MD, PhD*; and Gerhard A. Zielhuis, PhD‡

ABSTRACT. *Objective.* To test the hypothesis proposed in a recent French study that a history of recurrent otitis media (OM) in childhood increases susceptibility to hearing loss from frequent exposure to a personal stereo (PS) during development to early adulthood.

Methods. A subcohort of 358 young adults selected from a historic cohort study, all 18 years old and with a well-documented OM history (secretory and acute), provided data on the sound level and length of exposure to PSs. Four contrasting groups were formed: those with the highest or lowest PS exposure combined with a positive or negative history of OM ($n = 238$). The main outcome measure was hearing thresholds from pure-tone audiometry (0.5–8 kHz).

Results. Young adults with a history of recurrent OM in childhood did not show greater susceptibility to hearing loss from PS use than their peers without a history of OM. However, a history of recurrent OM was associated with significant mean air-conduction hearing loss of 4 dB and a mean bone-conduction hearing loss of 2 dB compared with the participants without a history of OM (Fig 1).

Conclusions. Recurrent OM in childhood may have an irreversible effect on the middle ear and the cochlea and may lead to hearing deficits in later life. No interaction with PS exposure is seen. *Pediatrics* 2003;111:e304–e308. URL: <http://www.pediatrics.org/cgi/content/full/111/4/e304>; *otitis media, otitis media with effusion, hearing, adolescence, long-term effects, audiometry, noise-induced hearing loss, personal stereos, cohort studies.*

ABBREVIATIONS. OM, otitis media; PS, personal stereo; dB HL, decibel(s) hearing loss; SPL, sound pressure level; OME, OM with effusion; OM+, positive OM; OM-, negative OM; PS+, high PS score; PS-, low PS score; AOM, acute OM.

Otitis media (OM) is one of the most common childhood diseases. Although it is responsible for a great deal of medical consultations, the clinical relevance of the disease has been repeatedly questioned. Controversy in management exists because of the large rate of spontaneous recovery, the low rate of complications, and the poor effective-

ness of medication (antibiotics) and surgery (ventilation tubes, adenoidectomy).^{1–4} Treatment with ventilation tubes has even shown adverse effects on hearing in the long-term. However, this was demonstrated in small numbers.⁵

Job and colleagues^{6,7} have published the results of an explorative study on conscripts for the French army, 18 to 24 years old. They found that the combination of a history of recurrent OM and exposure to personal stereos (PS) for >1 hour a day resulted in a mean hearing loss of 11 decibels hearing loss (dB HL) at 0.5 kHz to 8 kHz as measured by pure-tone audiometry. In contrast, hearing loss was not found to be associated with a history of OM without frequent PS exposure, or to frequent PS exposure without a history of OM. Therefore, Job et al hypothesized that persons with and without a history of OM in childhood have different susceptibility to hearing damage from PS exposure. Their study was criticized because of its explorative nature and the retrospective assessment of OM.^{8,9} A prospective follow-up study on children with a documented history of OM was recommended to test the hypothesis.

The otherwise healthy birth cohort of the Nijmegen OM Study¹⁰ provides a unique opportunity to perform this test, because data on OM have been meticulously documented. The aim of this study was to evaluate whether a history of recurrent OM in childhood increases susceptibility to hearing loss from frequent exposure to a PS during development to early adulthood.

POPULATION AND METHODS

Study Participants

A cohort ($n = 1439$) born in 1982–1983 formed the basis for this investigation.^{10,11} The vast majority of this birth cohort ($n = 1328$) had been screened for OM with effusion by means of tympanometry from 24 months old to 48 months old at 3 monthly intervals. At the first of these screenings, a thorough history of (treatment for) middle ear diseases had been taken from birth onwards. At 8 years, 946 children from this cohort had been reevaluated: extensive audiometrical assessment had been performed, and a detailed history had been taken focusing on (treatment for) middle ear diseases from 48 months old onwards. At the time of this study the participants were 18 years old. We were able to trace 677 of 946 who were reevaluated at 8 years. Participants were ranked according to the presence or absence of a history of OM by composing a cumulative score based on the documented number of episodes of either OM with effusion (OME) or acute OM (AOM) from birth to 8 years. In this cumulative OM score, OME was defined as the proportion of flat (type B) tympanograms or the presence of ventilation tubes out of all documented tympanometric measurements, while AOM was defined as the proportion of events of otalgia with fever and/or otorrhoea out of all documented reports.

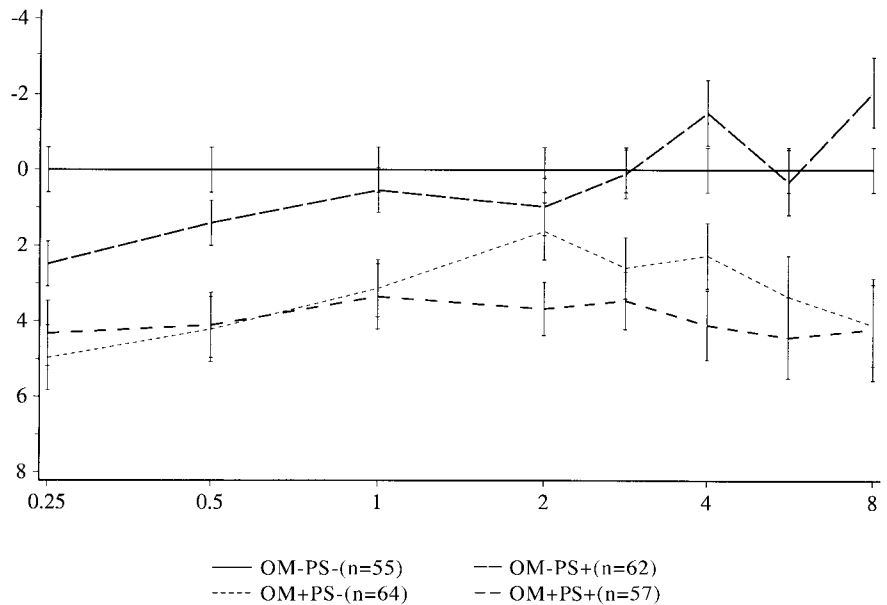
From the Departments of *Otorhinolaryngology and ‡Epidemiology and Biostatistics, University Medical Center Nijmegen, Nijmegen, the Netherlands.

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Reprint requests to (B.A.d.B.) Department of Otorhinolaryngology, University Medical Center Nijmegen, PO Box 9101, 6500 HB Nijmegen, the Netherlands. E-mail: b.debeer@kno.umcn.nl

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Fig 1. Mean air-conduction thresholds in participants with and without a history of OM and with and without PS use. All thresholds relative to the hearing level of the OM-/PS- reference group.



The OM score ranged from 0 to 200. The participants in the highest and lowest tertiles of this OM score ($n = 528$) were selected to form 2 groups with either a positive OM (OM+) or a negative OM (OM-) history. A total of 358 of these 528 persons agreed to participate in this study. Five participants were excluded from the analyses because of missing data, the presence of neurofibromatosis, bilateral OME, or congenital deafness. In 5 persons with a large unilateral tympanic membrane perforation, or unilateral eradication of a cholesteatoma, only the healthy ear was included in the analyses. A further subdivision was made of these 358 participants based on the use of a PS (vide infra).

Approval for the study was obtained from the Ethics Committee of the University Medical Center Nijmegen.

Exposure to Music From PSs

A PS exposure score was assessed for all the participants in the study. This PS exposure score was based on a combination of the cumulative length of exposure to a PS from the age of 8 years until the present and the sound level of the music typical for that individual. Information on the cumulative hours of exposure in each year the subject had used a PS was obtained using a standardized questionnaire with detailed questions. Information on the sound level was obtained during a PS listening test; participants were asked to bring their favorite disk with pop music and their PS, if available. The investigators provided standard headphones (Philips SBC HS500; Philips, Eindhoven, the Netherlands) or earphones (Sony D-C21; Sony, Tokyo, Japan). The participants were asked to listen to their favorite piece of pop music and to set the volume to the level they usually listened to. We then measured the A-weighted equivalent sound pressure level (SPL) of a 2-minute track with an integrating sound level meter (Brüell & Kjaer type 2260; Brüell & Kjaer, Naerum, Denmark) electrically coupled to the output of the PS. To obtain the actual SPL in the external ear canal, the head/earphones were calibrated on artificial ears (Brüell & Kjaer type 4152 and type 4153; Brüell & Kjaer).

The PS exposure score was calculated as the product of the cumulative length of exposure and the calibrated SPL, expressed in SPL per 24 hours and standardized to a SPL of 85 A-weighted decibels (the occupational noise exposure limit in the European Community), according to the model developed by Passchier-Vermeer.¹² Thus, for each individual the PS exposure score estimated the total sound energy accumulated over the years of exposure since the age of 8. All of the participants were ranked according to this score. Only the participants in the highest and lowest tertiles were selected for statistical analyses to compose a group with a high PS score (PS+) and a group with a low PS score (PS-).

To investigate separate and combined correlation between OM in childhood (OM+ and OM-), PS exposure (PS+ and PS-), and hearing levels at 18 years, 4 contrasting groups were formed:

OM-/PS-, OM-/PS+, OM+/PS-, and OM+/PS+ (total $n = 238$).

Outcome Measurements

All participants underwent standardized otomicroscopy of the external ear canal and the tympanic membrane.

Pure-tone audiometry was performed in an audiometric testing booth using an Interacoustic Clinical Audiometer (model AC40; Assens, Denmark) and Telephonics TDH 39P headphones (Telephonics, Huntington, NY) that were calibrated according to International Organization for Standardization 389 standards.¹³ Air-conduction thresholds were measured in both ears at the frequencies 0.25, 0.5, 1, 2, 3, 4, 6, and 8 kHz. Bone-conduction thresholds were measured in one ear at 0.5, 1, 2, 3, 4, 6, and 8 kHz. If the air-conduction thresholds exceeded +10 dB HL, bone-conduction thresholds were measured in both ears with standard masking techniques. Hearing loss was expressed in dB HL. The participants were asked to refrain from exposure to loud music during the 24 hours before these audiological examinations. A Danplex Tymp87 immittance meter (Danplex, Odense, Denmark) was used for tympanometry.

The participants also completed a questionnaire to obtain information on their otological status (including signs of auditory problems), participation in pop music activities (eg, visits to discotheques, rock concerts, or house parties and employment as a disk jockey or stage technician), and on exposure to noise at work or during recreational activities. Occupational noise exposure was defined as having worked in noise for longer than 6 months without any appropriate ear protection. Exposure to recreational noise included playing a musical instrument, being actively involved in indoor ball sports, riding a motorcycle, shooting or hunting, and operating model cars or planes. All questions pertained to the past 10 years, ie, the period since the previous follow-up evaluation.

Self-reported middle ear disease was verified with data from the medical records with the consent of the participants.

Statistical Analysis

Principal analyses focused on differences in the distribution of average hearing level in individuals at the frequencies 0.25 kHz to 8 kHz. Differences between groups were tested by Student's *t* test and analysis of variance at each frequency. Gender and exposure to sources of noise other than a PS (occupational noise, recreational noise, and noise from participation in pop music activities) were evaluated as potential confounders.

All analyses were performed with SAS statistical software (version 6.12; SAS, Cary, NC).

TABLE 1. Distribution of Gender, OM History, PS Use, and Exposure to Noise Other Than a PS in the 4 Contrasting Groups

	OM−/PS− (<i>n</i> = 55)	OM−/PS+ (<i>n</i> = 62)	OM+/PS− (<i>n</i> = 64)	OM+/PS+ (<i>n</i> = 57)
Male	45%	40%	44%	49%
OM score*†	9 (0–22)	9 (0–21)	64 (42–113)	73 (47–130)
OME‡	4 (0–21)	0 (0–13)	46 (20–79)	45 (14–83)
AOM§	0 (0–18)	9 (0–18)	27 (0–55)	30 (0–70)
PS score*	0.2 (0–0.4)	5.4 (2.2–43.0)	0.2 (0–0.5)	9.3 (2.3–87.3)
Work in noise¶	4%	11%	9%	25
Pop music activities*#	184 (21–446)	276 (18–488)	219 (26–467)	297 (90–656)

* Median (P_5 – P_{95}).

† Proportion of cumulative number of OM episodes during childhood (0 to 8 years old) out of all documented measurements (range 0–200).

‡ Proportion of cumulative number of OME episodes during childhood out of all documented measurements (range 0–100).

§ Proportion of cumulative number of AOM episodes during childhood out of all documented measurements (range 0–100).

|| Value of the total sound energy due to PS exposure expressed in equivalent years of continuous exposure to 85 A-weighted decibels.

¶ Proportion of subjects with occupational noise exposure for longer than 6 months without any appropriate ear protection.

Cumulative frequency of exposure to pop music activities other than PS use.

RESULTS

Each of the 4 contrasting groups (OM−/PS−, OM−/PS+, OM+/PS−, OM+/PS+) contained 55 to 64 participants 18 years old (Table 1). The distributions of OM scores did not differ significantly between the 2 OM− groups (median 9) or between the 2 OM+ groups (median 63 and 72, $P > .05$). The distributions of the PS scores did not differ between the PS+ and PS− groups. In the OM+/PS+ group, more participants had been exposed to occupational noise without any ear protection than the other groups ($P < .01$). The 2 PS+ groups had been exposed to more pop music activities than the 2 PS− groups ($P < .01$). Discotheque visits contributed most to the cumulative exposure to pop music activities. Exposure to recreational noise was rare and equally distributed over the 4 groups (data not shown).

Air-conduction thresholds from pure-tone audiometry are plotted in Fig 1 for the 3 groups with exposure to OM and/or PS, relative to the hearing thresholds in the OM−/PS− reference group. When we compared PS+ to PS− for each stratum of the OM score, the audiograms appeared to be fairly similar. No significant difference in hearing threshold could be demonstrated at any of the frequencies, except for 0.25 kHz in the OM− groups ($P > .10$). In contrast, there was a significant difference in hearing thresholds between the OM+ and OM− groups that was independent of the PS score. Participants in the OM+ groups showed consistently higher air-conduction thresholds (~4 dB HL) than the corresponding OM− groups at all the frequencies from 0.25 kHz to 8 kHz (Fig 1). The differences were significant when the 2 strata for PS were merged ($P < .01$).

We also evaluated potential confounders, such as exposure to other sources of noise. Exposure to occupational noise, recreational noise, and noise resulting from pop music activities did not have any significant effect on hearing.

To further explore the lack of correlation between PS use and hearing acuity, analyses were performed

on the participants whose PS exposure score was in the upper 15% (PS++) of the PS+ group. Again, no significant differences in hearing thresholds were found between the PS++ group and the PS− group ($P > .10$).

In the subsequent analyses, the PS+ groups and the PS− groups were merged to increase power. Fig 2A shows the air-conduction thresholds, while Fig 2B shows the bone-conduction thresholds for the OM+ and the OM− groups. Fig 2A shows that air-conduction thresholds in the OM+ group were ~4 dB HL poorer than those in the OM− group. Fig 2B shows that part (~2 dB) of the difference in air-conduction thresholds between the OM− and OM+ groups was a result of differences in bone-conduction thresholds, as the latter were significantly affected at all frequencies except for 2 kHz.

DISCUSSION

The aim of this study was to investigate whether repeated OM episodes in early childhood or infancy led to increased sensitivity to hearing loss because of frequent PS use in later childhood and adolescence. We did not find any evidence of a differential effect of PS exposure in participants with and without a history of OM in childhood. As the quality of our data can be considered superior to that in the study by Job et al,^{6,7} we assume that the interaction effect found by Job et al is a chance finding.

Regardless of the OM history, we did not find any significant correlation between frequent PS exposure and hearing acuity. This is in accordance with the observations of Job et al,^{6,7} who showed a small but nonsignificant effect. The same has been demonstrated in several other cross-sectional and longitudinal investigations.^{14–17}

The most striking result in the present study was that the hearing thresholds in the participants with a documented history of recurrent OM episodes in childhood were significantly poorer than those in the participants without a history of OM. Data on occurrence of OM (secretory and acute) had been objec-

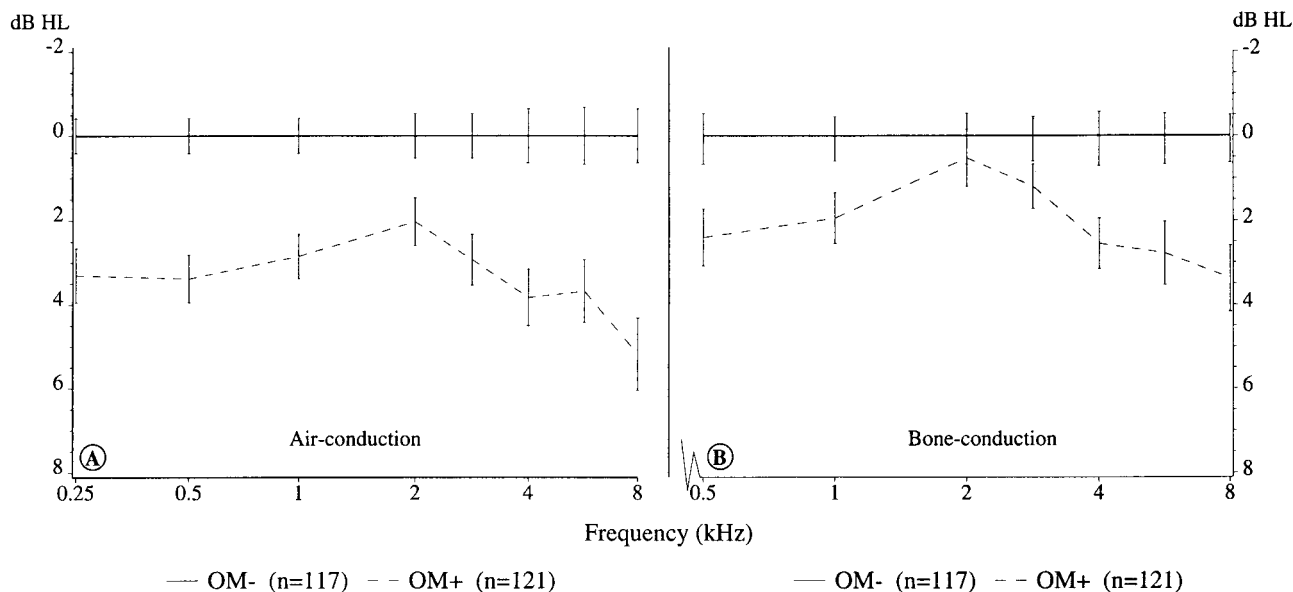


Fig 2. Mean air-conduction (A) and bone-conduction thresholds (B) in participants with a history of OM ($n = 121$) relative to the hearing level of the OM- reference group ($n = 117$).

tively documented for each individual over the period from birth to 8 years. In addition, the data on the sound level and duration of exposure to pop music from a PS were accurately documented. Furthermore, we controlled for all additional deleterious effects on hearing that occurred in the period between childhood and early adulthood. Hearing loss could not be explained by differences in PS exposure, occupational noise exposure, or noise exposure from recreational activities or from pop music activities. Therefore, we consider that we have strong arguments on which to base our conclusion that the association between recurrent OM episodes in childhood and poorer hearing in later life is unequivocal. This conclusion is supported by other publications in which it was suggested that OM in childhood (or its treatment) led to hearing deficits in the long-term.^{18–21} However, the follow-up periods in the latter studies were shorter and the population sizes were smaller.

We observed that the subgroups of young adults with and without a documented history of OM had different air-conduction thresholds (mean difference of 4 dB) and different bone-conduction thresholds (mean difference of 2 dB). It seems that OM has caused irreversible damage to the middle ear as well as the cochlea. The pathophysiological mechanisms responsible for these effects remain to be investigated.

This 4-dB difference in mean hearing level between young adults with or without a history of OM should not be disregarded, although it might seem irrelevant in clinical practice. This value concerns the mean difference in hearing acuity, which might have a substantial impact on a population level.²² The relevance of our finding is further supported by Brooks,²³ who estimated that elderly with mixed hearing loss (ie, a combination of sensorineural and conductive deficits) caused by middle ear disease in

childhood would be in need for a hearing aid 10 years earlier (ie, from 75 years old to 65 years old).

CONCLUSION

Some important points for consideration in current clinical and public health practice are as follows:

- Exposure to pop music from PSs at the levels established in this population had not led to any measurable hearing deficits.
- In this population, a history of OM in childhood had not increased susceptibility to hearing loss of exposure to pop music from PSs during development to early adulthood, which contradicts the hypothesis proposed by Job et al.^{6,7}
- Contrary to the prevailing belief, recurrent OM in childhood should be taken seriously because it might lead to hearing deficits in young adulthood.

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