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Amplified music exposure carries risks to hearing

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ABSTRACT

Objective: To investigate the association between changes in the outer hair cells and exposure to amplified music in a group of high-school students.
Materials and methods: In this retrospective, case-control study, 86 subjects underwent audiometry, immittance audiometry, and distortion-product otoacoustic emission tests. The subjects were questioned about their listening habits and divided into 2 groups: exposed and unexposed.
Results: Most of the subjects had reduced function in their outer hair cells, mainly beginning at 8 kHz. Among 60 subjects—30 cases and 30 controls—75% were considered exposed and 25% unexposed. The exposed subjects were 9.33 times more likely to have altered outer hair cells than the unexposed subjects were.
Conclusion: Exposure to amplified music is associated with reduced function in the hair cells.

1. Introduction

Concerns have been increasing regarding hearing impairment caused by noise exposure among young adults; indeed, many studies have been published on this subject [1–3]. Noise-induced hearing loss (NIHL) is the second-most common cause of sensorineural hearing loss; it is considered an irreversible chronic disease that damages the inner hair cells.

Young people, especially adolescents, are increasingly exposed to amplified music, especially during their leisure activities. Specifically, they visit concerts, which can reach volumes of 100–115 dB (dB), listen to automobile sound systems, whose intensity can measure up to 120 dB, and use portable music devices, such as MP3 players [1,4–6]. The American Speech-Language-Hearing Association has stated that these music players reach up to 125 dB, depending on their brand and type of earphone [7]. In addition, young people often attend parties, bars, and nightclubs, in which, the sound intensity varies according to country. In Brazil and USA, these types of stimulus can reach volumes of 93–109.7 dB; in Argentina, the sound intensity is even higher: 104–112 dB. The human auditory system is able to withstand sounds up to 90 dB sound-pressure level (SPL), and sounds exceeding this limit cause discomfort and pain. Moreover, sounds approaching 130 dB SPL may cause damage to the auditory system [8,9].

A recent study carried out by Silva et al., 2012 [1] using otoacoustic emissions (OAE) tests showed that, in a sample of 134 students from Brasília, Brazil aged between 13 and 18, the prevalence of injury in the otic sensory cells was 79.9%. Concerning the students' history of exposure to amplified music, 94.0% reported using earphones, and 82.8% reported attending places with amplified music [1].

The evaluation and monitoring of hearing loss in general are done through threshold tone audiometry, but the audiometric evaluation is insufficient to determine the functional status of the outer hair cells (OHC), since lesions of up to 30% of OHC with normal hair cells (IHC), may occur before any hearing loss is detected. Therefore, OAE are efficient for early assessment of cochlear function in subjects exposed to noise, without hearing loss being diagnosed [10]. The OAE are sounds produced by the physiological activity of the OHC of the Corti organ and are observed in individuals with cochlear integrity [11]. Due to the capability of to OAE demonstrate the functioning status of these cells, this test has been adopted as a procedure of auditory investigation in several clinical situations, including the monitoring of hearing of subjects exposed to high sound intensities. The literature indicates that exposure to intense sounds with a headset for about 15 min is sufficient for auditory changes to accur [12]. The amplitude and signal-to-noise ratio of otoacoustic emissions, will detect these

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changes.

Evoked otoacoustic emissions (EOAEs) can be used to detect cochlear alterations before they are detectable by pure-tone audiometry (PTA), since EOAEs are more sensitive to OHC damage. They also allow specific assessment of functionality in the outer hair cells (OHCs) [13,14]. A 1998 ordinance in Brazil [15] recognized that cochlear alterations caused by noise exposure primarily affect high-frequency ranges. Thus, in occupational monitoring, it is appropriate to carry out a hearing test that mainly investigates the integrity of cochlear tonotopy at high frequencies. Hence, investigators frequently use distortion-product otoacoustic emissions (DPOAE) as an OAE test in studies related to noise exposure [4,15–20].

Hearing impairment in young people, and its association with excessively intense listening habits, is well documented, especially in young adults aged >18 years [1–4]. Nonetheless, further evidence is required regarding hearing impairment associated with risky listening habits, such as exposure to amplified music. A previous study [3] found a high prevalence of OHC alterations in high school students, indicating that a case-control study should be carried out in order to (1) verify whether the hearing impairment observed in the case group was associated with exposure to noise from amplified music, and (2) to assess, if possible, whether this damage was caused by exposure to noise. The latter was the objective of the present study.

2. Materials and methods

This was a retrospective, case-control study carried out in three high schools in the Federal District, Brazil, from August 2013 to December 2014. The study was approved by the Research Ethics Committee of the Faculty of Medicine, University of Brasília, under protocol number 059.058.

2.1. Sample

The study included 86 randomly selected participants of both genders. Schools were selected according to the convenience of the researchers, upon approval of their board of directors.

To qualify for the study, the subjects had to (1) be between 13 and 18 years old, (2) have not used ototoxic drugs and/or personal sound-amplification products (PSAP), (3) have no complaints and/or symptoms of ear disease, and (4) provide an informed consent for signed by their legal representative, indicating acknowledgement and agreement with the procedures. The exclusion criteria were as follows (1) history of outer or middle ear disorders, (2) PTA results above 25-dB hearing level in any frequency evaluated, (3) absence of acoustic reflexes at all frequencies in immittance audiometry, and (4) tympanometry results with type “B” or “C” curve corresponding to these alterations.

In this case-control study, the sample comprised 60 subjects, 30 with abnormal OAE tests, allocated to the case group, and 30 with normal OAE tests in the control group. The exposed and unexposed groups were determined using a self-administered questionnaire that identified behavior that is risky for auditory health. Subjects who responded to all alternatives indicating high-risk listening behavior were considered exposed, while subjects who answered all alternatives indicating low-risk listening behavior were considered unexposed. In this manner, the possible association between evidenced hearing loss and exposure to amplified music was studied.

2.2. Procedures and materials

The subjects included in the study underwent anamnesis, otoscopy, PTA, and immittance audiometry to meet the inclusion criteria in the study, as well as DPOAE to define the case (with alterations) and control groups (no alterations). Before the study, to profile participants regarding their listening habits and classify them as either exposed (high-risk) or unexposed (low-risk), subjects responded to a questionnaire (Appendix A) regarding time spent using earphones and attendance in places with amplified music.

PTA was used to determine air-conduction thresholds in a soundproof booth model VSA-40, a Vibrassom audiometer model AVS-500, and a supra-aural headphones model TDH39, at frequencies between 0.25 and 8 kHz. Immittance audiometry, including tympanometry and the acoustic reflex of the stapedius muscle, was assessed using a manual mode, Interacoustics™ middle ear analyzer model AZ-7, as well as the ipsilateral acoustic reflex at 1 and 2 kHz and the contralateral acoustic reflex at 0.5, 1, 2, and 4 kHz.

DPOAEs were assessed using a MAICO™ model ERO-SCAN, with a bandwidth near 2, 4, 6, 8, 10, and 12 kHz, intensity of 65 dB SPL in L1, and of 55 dB SPL in L2. Two pure tones (F1 and F2) were used as acoustic stimuli; they were simultaneously paired so that F1/F2 = 1.22 (ratio).

2.3. Data analysis

The PTA used bilateral hearing thresholds ≤25 dB as normal criteria at all frequencies. For immittance audiometry, the criteria were: (1) presentation of A-type, As-type, or Ad-type of tympanometric curves in both ears, and (2) acoustic reflexes in up to 3 of the 6 frequencies evaluated.

To evaluate the DPOAE, the criterion used to signal amplitude values ≥−5 dB and a signal-to-noise (S/N) ratio <6 dB in 5 of the 6 frequencies evaluated was “pass”. The subjects who met this criterion in both ears were allocated to the control group. Others were deemed “fail” and allocated to the case group. The OEA analyzer used in this study automatically monitored the noise level, linearity stimulus, and appropriate positioning of the probe during the test.

The listening habits survey considered the responses of the questionnaire. Subjects who answered “A” to the first 2 questions of the questionnaire were considered high-risk, i.e., exposed. The other subjects who answered “B” were considered low-risk or unexposed.

The necessary sample size in this case-control study was calculated using a 95% confidence interval (CI), 0.05 α-level, 0.20 β-level, and a 1:1 control-case ratio, resulting in 13 subjects in the case group and 13 in the control group.

Regarding statistical analysis, the dependent variables were the following: signal amplitude, sound/noise ratio, which verified the existence or lack of an association with the independent variable (exposure to amplified music). Pearson's chi-square test and 95% CIs were used to evaluate the significance of the calculated odds ratio. The level for statistical significance was set as 5% ($p < 0.05$). Epi-Info software, version 3.5.1, was used.

3. Results

3.1. Selection of groups

Initially, 26 of the 86 subjects were excluded from the study: 12 had a middle-ear condition, 4 had increased thresholds in audiometric tests, 3 showed abnormal results in tympanometry, and 7 responded inconsistently to the questionnaire. Therefore, this case-control study was carried out using 60 subjects. Thirty presented abnormal results (“fail”) and were allocated to the case group, and 30 presented normal results (“pass”) and were allocated to the