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Original Article

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Key Words
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Music-induced hearing loss

Music exposure and audiological findings in Brazilian disc jockeys (DJs)

Exposición a la música y hallazgos audiológicos en Disc Jockeys (DJs) Brasileños

Abstract
The aim of this study was to examine the music exposure and hearing of disc jockeys (DJs). We conducted personal noise dosimetry on 30 DJs and interviewed them regarding their hearing and their job. We conducted pure-tone audiometry, and transient and distortion product otoacoustic emissions before their exposure to music during their work. This first test was preceded by a period of at least 12 hours without exposure to music or noise. We repeated the pure-tone audiometry and otoacoustic emissions after their music exposure, and poorer performances were registered in all retests. The nightclubs' average sound level ranged between 93.2 to 109.7 dB(A). Statistical analysis showed significant bilateral temporary threshold shifts at all frequencies between audiometry performed pre- and post-exposure to amplified music. Transient otoacoustic emissions showed a significant difference in bilateral amplitude and reproducibility at all frequency bands tested. The comparison of distortion product otoacoustic emissions results pre- and post-music exposure showed there was a significant difference in amplitude. Music exposure was associated with temporary and permanent auditory dysfunction among professional DJs.

Sumario
El propósito de este estudio fue examinar la exposición a música y la audición de los *disc jockeys* (*DJs*). Realizamos una dosimetría de ruido en 30 *DJs* y los entrevistamos en relación con su audición y su trabajo. Realizamos audiometría de tonos puros (ATP) y emisiones otoacústicas con transitorios (EOAT) y productos de distorsión (EOAPD) antes de la exposición a la música en su trabajo. La primera prueba fue precedida por un período de al menos 12 horas sin exposición a música o ruido. Repetimos la ATP y las EOA después de la exposición a la música y se registraron rendimientos más pobres en todas las pruebas. El promedio de los niveles de ruido en los centros nocturnos varió de 93,2 a 109.7 dB(A). El análisis estadístico mostró cambios significativos de umbrales en todas las frecuencias entre las audiometrías realizadas antes y después de la exposición a la música amplificada. Las EOAT mostraron bilateralmente una diferencia significativa en su amplitud y en su reproducibilidad en todas las bandas de frecuencia probadas. La comparación con los resultados de las EOAPD antes y después de la exposición mostraron que había una diferencia significativa en la amplitud. La exposición a música se asoció con disfunción auditiva temporal y permanente en los *DJs* profesionales.

In recent years, the term music-induced hearing loss has begun to be used for a condition akin to noise-induced hearing loss. Both noise- and music-induced hearing loss are characterized by a notch in the 4000 to 6000 Hz region of the audiogram, are linked to a chronic, extended exposure, and progress at rates proportionate to exposure conditions. But noise is defined as an unwanted sound, whereas music is often quite the opposite. Some reports have indicated that music exposure is less damaging than noise of equal energy, both in terms of temporary and permanent shifts (Axelsson and Lindgren, 1978, 1981a,b; Axelsson and Lindgren, 1983; Lindgren and Axelsson, 1983; Hellstrom et al, 1998).

Noise is the leader among the complaints to the Environmental Health Department not only in Curitiba but in many other state capitals in Brazil. Still, many young people expose themselves, for hours, to electronically amplified music levels that could be harmful to their hearing. Increasing attention is being given to the auditory effects of music exposure, both among the musicians as well as among those who attend concerts and nightclubs, or use cassette tape players, CD players, MP3 players etc. The effects of occupational exposure to music among other staff such as waiters, bartenders, doormen, etc have received comparatively less attention (Axelsson and Clark, 1995; Meyer-Bisch, 1996; Lee, 1999; Kähäri et al, 2002; Schmuziger et al, 2006).

In a study conducted in five nightclubs in Singapore, the music exposure and the hearing of disk jockeys, bartenders, waiters, doormen, and bouncers were evaluated (Lee, 1999). Personal noise dosimetry was carried out on 40 employees throughout their work shift. Their audiometric examination results were compared with 37 subjects from a non-exposed control group. The discotheque group had a statistically significant higher prevalence (41.9%) of early sensorineural hearing loss (pure-tone thresholds greater than 30 dB at 4000 and/or 6000 Hz) compared to the control group (13.5%). All the occupational groups were exposed to music levels of at least 89 dB (A) L_{eq} for their whole work shift. The study showed that all the employees, regardless of their occupation, were exposed to noise above internationally recommended limits of 82–85 dB(A) and were at a higher risk of early sensorineural hearing loss and tinnitus than the participants from the non-exposed group. Similar findings were reported among DJs in Brazil, whose results indicated audiometric configurations compatible with early stages of

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music-induced hearing loss (MIHL), i.e. a notch in the high frequencies (Sisnando, 2002).

Both transient-evoked and distortion product otoacoustic emissions (TEOAEs and DPOAEs) have been used to investigate the effects of noise and music exposure on cochlear function, since both provide frequency-specific information. Moreover, it has been suggested that otoacoustic emissions are a more sensitive test of cochlear function than pure-tone audiometry since they indicate subclinical cochlear damage that is often encountered in patients with noise-induced hearing loss (Balatsouras, 2004; Prasher & Sulkowski, 1999). Several authors have argued that otoacoustic emission testing can contribute to an early identification of noise-induced auditory effects (Avan and Bonfils, 2005; Desai et al, 1999; Avan et al, 1995). However, there is no consensus on which protocol and which test (TEOAEs or DPOAEs) would be best for this use.

Studies with experimental animals that have been exposed to high exposure levels have reported a decrease in the amplitude of the OAEs response (Lonsbury-Martin et al, 1987; Schmiedt, 1986), but in humans there are few reports on the OAEs response changes in cases of temporary threshold shifts. Otoacoustic emissions have been used to examine auditory effects in people who usually go to discos. One study used pure-tone audiograms, TEOAEs, and DPOAEs to evaluate 46 disco visitors exposed to disco music at an average intensity of 105 dB (A) for 1, 1.5, and 2 hours (Liebel et al, 1996). Threshold shifts occurred in the 4000 Hz range in the 1-hour group and spread over all frequencies as exposure time increased. The average pure-tone threshold shift over all tested frequencies was 6.2 dB for the 1-hour group, 7.1 dB for the 1.5-hour group, and 10.1 dB after 2 hours of music exposure. TEOAE amplitudes showed significant reduction only at 2000 and 3000 Hz post-music exposure. A reduction of TEOAE amplitudes occurred when pure-tone threshold shifts exceeded 15 dB in some cases. Similar results were obtained in the DPOAE measurements, post-music exposure. The authors indicated that they did not consider TEOAE and DPOAE to be ideal instruments in the detection of temporary threshold shift after noise exposure when using the test parameters in the study, and that pure-tone audiometry was still necessary. A more recent study (Mansfield et al, 1999) examined 28 young adults whose only significant source of noise exposure was loud music. Differences between more exposed and less exposed groups of ears were most marked in the 2000 Hz half-octave band for right ears, and in the 2800 Hz half-octave band for left ears.

In an interview for a study conducted in Scotland, UK, 70% of 23 DJs reported temporary threshold shift after work sessions, and 74% of them reported tinnitus. Audiometric results revealed three cases of music-induced hearing loss (Bray et al, 2004). The average sound pressure level for a typical nightclub was 96 dB(A), but exposure levels of up to 108 dB(A) were observed in some of the nightclubs.

In England, UK, the Royal National Institute for the Deaf (RNID) interviewed people for the hearing loss prevention campaign, *Don't Lose the Music,* and reported that 75% of those interviewed complained of tinnitus and half of them indicated that excessive sound pressure levels had caused it. The RNID argued that the public views DJs as setting an example, and they could be used to model certain behaviors. The RNID developed a campaign suggesting simple measures such as avoiding being too close to loudspeakers or using hearing protection to guard against MIHL (Yahn, 2003).

The objective of the present study was to measure the sound pressure level of the music exposure that DJs experience at work in different nightclubs, and to evaluate the auditory effects of amplified music from their jobs using pure-tone audiometry and otoacoustic emissions testing. Both distortion product and transient-evoked otoacoustic emission tests were used to evaluate the potential contribution of each to the examination of the effects of occupational exposure to music.

Material and Methods

Participants were interviewed regarding demographic factors, their health and hearing, job, and music exposure histories. Each participant was interviewed twice, before and after exposure to amplified music.

Study population

A local association of professional musicians indicated that until 2004 (when data collection took place) there were approximately 90 professional DJs in the city of Curitiba. We were able to locate 60 DJs, and letters were sent to those individuals inviting them to be in the study; 35 responded, agreeing to participate. From the 35 DJs who agreed to participate, 32 were males; three females were not included in the study to exclude the variable of gender from the analysis. Two other DJs were excluded because they showed middle ear alterations (type B tympanogram) and were referred for medical treatment of their condition. The 30 participants worked in five different nightclubs. Their exposure to music during work was measured. The present study was approved by the Committee of Ethics at the Universidade Tuiuti do Paraná, process number 92/2004. All participants signed a consent form before participating in the study.

Personal noise dosimetry

Noise dosimetry was conducted in this study to illustrate exposure levels to which DJs are exposed in different nightclubs, and not for the estimation of damage-risk relationships. Sound pressure level measurements were done using a Bruel & Kjaer noise dosimeter, model 4431, which was set up by an audiologist under the supervision of an engineer. Brazilian regulations and manufacturer recommended procedures were used. The equipment underwent calibration before the measurements were conducted. The microphone was clipped to the DJs' lapel, next to their ear. The DJs used one headphone to monitor the music being played. They asked that the dosimeter microphone be clipped on the opposite side of the headphone so it would not be in their way. Seventy percent of the participants used the headphone on their left ear, and for those, the microphone was placed by their right ear (vice-versa for the remaining 30% of the study population). The dosimeters stored the maximal sound level every second (time weighting fast, exchange rate 5 dB).

Only 21 DJs allowed sound pressure level measurements. Some did not give a reason for not allowing the measurements, while others indicated that they were concerned that it could distract them, influence their performance, or they just did not want it done.

The sound pressure level measurements were conducted on the same night as the audiological tests were performed. The sound measurements lasted up to two hours, since this is the typical duration of their shift, or set, in one nightclub.

The DJs work routine is highly variable, and rather unpredictable. They can work in up to three different nightclubs in one night. They sometimes stay in the same nightclub, working another set later. They can leave the club after their set if they do not have another job, but indicated they usually stay in the nightclub. They indicated that their music exposure usually lasts eight hours per night, from 10 pm to 6 am, and that they work up to four nights a week. The routine also varies weekly.

Audiological assessment

A Volkswagen bus, modified for use as a mobile laboratory, was equipped with a soundproof booth which met the requirements of ANSI S 3.1-1991 for audiometric testing environments. The audiological tests were conducted by certified audiologists.

Participants had their hearing evaluated before, and a few minutes (up to ten minutes) after, the exposure at work to electronically amplified music. Before the first test we confirmed with each participant if he had been away from noise or music exposure for at least 12 hours, which was a condition for the testing at that opportunity. To assess the workers' hearing status, otoscopy, pure-tone audiometry, immittance audiometry, distortion product, and transient-evoked otoacoustic emissions were performed. Otoscopy and tympanometry were performed to screen for conditions that would exclude the person from the study, i.e. external otitis, perforated tympanic membrane, or tympanogram tracing types B and C (Jerger, 1970). Only participants with a type A curve in both ears were included in the study. The equipment used was Interacoustics model AT 235.

Immediately following their exposure to amplified music during their work shift participants underwent a second pure-tone audiometry and otoacoustic emissions test, described in detail below.

PURE-TONE AUDIOMETRY

Pure-tone audiometry was performed for all subjects at the frequencies of 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz. Thresholds were considered as normal if they were equal or less than 25 dBHL. Bone conduction testing was performed for the affected frequencies in the range of 0.5 to 4000 Hz. The Interacoustics AC 40 audiometer was calibrated to ISO R389-1964 standard prior to the data collection. Daily biological calibration checks were also performed immediately before testing subjects.

Both mean and median audiometric thresholds pre- and post-music exposure were calculated. These were not significantly different from one another. Since the study population was relatively small and potentially highly influenced by extreme values, we opted to report median values. Student paired t-tests were used in the data analysis of pre- and post-music exposure audiological test results.

OTOACOUSTIC EMISSIONS

The Otodynamics Ltda ILO96 Research OAE System was used for the evoked otoacoustic emissions tests.

TEOAES TESTING

Each TEOAE test was conducted with the noise-rejection level at 47.3 dB peak. The transient stimulus used was a non-linear click, at an intensity of 80 dB. The stability of the probe was always higher than 80% and it was calibrated before data collection each day using the probe test option (in the ILO menu) and a 1 cc acoustic calibration cavity.

Reproducibility of 50% or greater, with an amplitude of response greater or equal to 3 dB was used as the response criterion for TEOAEs (Kemp, 2002).

DPOAES TESTING

The amplitude of the DPOAEs was plotted in a DPgram. The primary frequencies selected for evaluation provided a DPgram at the geometric mean frequencies of f_1 and f_2 at 1000, 1500, 2000, 2500, 3000, 4000, 5000, and 6000 Hz; the proportion f_2/f_1 was 1.22. L_1 was 65 dB HL, while L_2 was 55 dB HL. The examination was conducted in steps of 3 points/octave using the conventional $2f_1 - f_2$ method. We adopted a criterion threshold of 3 dB above the noise floor. The criteria utilized to indicate the occurrence of the DPOAEs was that the amplitude of the response (signal-to-noise ratios or SNRs) should be at least 6 dB SPL above the first deviation of the noise standard equivalent of the tested frequency, or 3 dB above the second deviation of the noise standard (Gorga et al, 1993). The absolute amplitudes recorded before and after music exposure were also analysed using the Paired T-test.

Results

Interview

The study group mean length of music exposure as a DJ was 7.2 years (s.d. 5.3 years), ranging from one to 20 years. Their mean age was 27 years (s.d. 5.9 years), ranging from 17 to 39 years of age.

Ninety percent of the DJs described their hearing as good, and 33% indicated using hearing protection infrequently (10 DJs reported having tried using it, but not often, while 20 indicated they have never tried it). Seventy percent of the participants used one headphone on their left ear to monitor the music being played, the remaining 30% used it on their right ear. The most frequent complaints immediately after music exposure were bilateral tinnitus (66.7%) and feeling fullness in the ear (26.7%).

Even when the DJs learned about the test results, they indicated that they did not think the situation needed any change. They indicated they would like to learn more about flat attenuation ear plugs, but did not anticipate starting to use them.

Sound pressure measurements

The duration of each measurement and the results for average sound levels for the measurement period based on a 5 dB exchange rate (L_{avg} 5) ranged from 93.2 to 109.7dB (A), as can be seen in Table 1. The permissible exposure limit used in these calculations was the one from the Brazilian Occupational Legislation, which is 85 dB (A) for eight hours of music exposure, with a 5 dB exchange factor.

Table 1. Results for average sound levels (L_{avg}) for the measurement period based on a 5 dB exchange rate

Location	*Subject (DJ)*	*L_{avg} 5 (dBA)*	*Duration of measurement*
Club 1	1	108.5	2 h 20 min
Club 1	2	107.3	1 h 15 min
Club 1	3	108.2	1 h 10 min
Club 1	4	109.1	1 h
Club 1	5	109.7	1 h 30 min
Club 2	6	95.6	1 h 30 min
Club 2	7	93.2	1 h 30 min
Club 2	8	93.9	2 h
Club 2	9	100.3	1 h 10 min
Club 3	10	101.6	1h
Club 3	11	105.8	1 h 40 min
Club 3	12	99.4	1 h
Club 3	13	95.8	2 h
Club 3	14	105.9	1 h 10 min
Club 4	15	94.8	1 h 20 min
Club 4	16	97.1	1 h
Club 4	17	105.6	1 h 30 min
Club 4	18	98.3	2 h
Club 5	19	95.2	1 h 20 min
Club 5	20	107.8	1 h 30 min
Club 5	21	107.6	2 h

Audiological assessment

Pure-tone audiometry

We observed that out of the 30 participants, 11 of them (27%) already had thresholds equal to or poorer than 25 dBHL in the frequency range between 3000, 4000, 6000, and 8000 Hz. The poorest measured threshold was 50 dB in 6000 Hz in one ear.

Temporary threshold shifts from 5 to 30 dBHL occurred mainly in the frequencies of 3000, 4000, and 6000 Hz. The pre- and post-music exposure median audiograms are displayed in Figure 1.

Statistically significant differences between the pre- and post-music exposure thresholds were observed in all the test frequencies, in both ears (Table 2). The post-exposures thresholds were poorer than the pre-exposure ones.

Table 3 displays the number and percentage of ears with temporary threshold shift, by test frequency, by ear.

Transient evoked otoacoustic emissions

Figure 2 (a,b) illustrates the number of individuals with presence of a TEOAE response, by frequency band, pre- and post-music exposure to amplified music.

Table 4 displays the results of the comparison of the signal-to-noise ratios of TEOAEs pre- and post-music exposure. Statistically significant differences can be observed in all frequency bands for both ears, revealing a decrease in response following music exposure. In Table 5, the comparison of the reproducibility of the TEOAEs pre- and post-music exposure during their work is displayed. Statistically significant differences were observed for all frequency bands for both ears.

Distortion product otoacoustic emissions

In Figure 3 (a,b) we can observe the number of individuals with the presence of a DPOAE response at the different frequencies before and after exposure to electronically amplified music. Table 6 displays the results in the comparison of the absolute amplitude of the DPOAE before and after the DJs' exposure. In the right ear statistically significant differences in absolute amplitude were registered at the frequencies of 2002, 2515, and 6348 Hz. In the left ear, statistically significant differences in the absolute amplitude were registered in all the frequencies, except in 1587 and 2002 Hz.

Paired t-test results revealed no significant differences between the results of the left and right ears, in none of the tests (pure-tone audiometry, TEOAE and DPOAE) performed pre- or post-music exposure.

Discussion

The objective of the present study was to examine the occupational exposure to music and the hearing of DJs. Average sound levels for the measurement period, based on a 5 dB exchange rate (L_{avg} 5) in the five nightclubs surveyed, ranged between 93.2

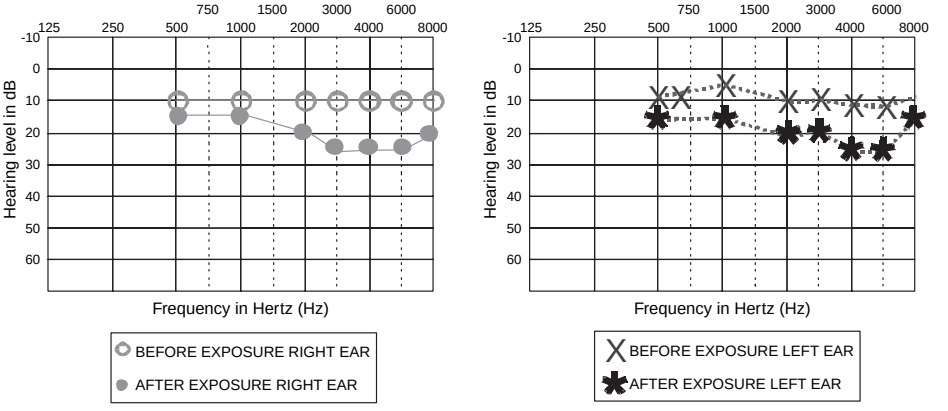

Figure 1. DJs' median audiograms pre- and post-music exposure.

Table 2. Paired t-test results: Comparison of the DJs' audiometric thresholds (and standard deviations, s.d.), pre- and post-music exposure (RE = right ear; LE = left ear)

Frequency (kHz)	*n*	*RE/ pre exp. Threshold*	*/s.d.*	*RE/post exp Threshold*	*/s.d.*	*t*	*p*
0.5	30	10	5.0	15	5.5	−6.30	0.000001
1	30	10	4.5	15	5.7	−6.48	0.000000
2	30	10	6.2	20	7.0	−7.44	0.000000
3	30	10	9.3	25	9.5	−8.90	0.000000
4	30	10	9.6	25	11.5	−8.72	0.000000
6	30	10	11.2	25	14.5	−6.81	0.000000
8	30	10	12.2	20	12.0	6.28	0.000000
		LE/ pre exp. Threshold	/s.d.	LE/post exp. Threshold	/s.d.		
0.5	30	10	4.8	15	6.1	−5.29	0.000001
1	30	5	4.5	15	6.2	−6.70	0.000000
2	30	10	8.3	20	10.3	−8.23	0.000000
3	30	10	9.2	20	9.8	−8.53	0.000000
4	30	12.5	11.4	25	10.8	−8.39	0.000000
6	30	12.5	12.1	22.5	12.4	−7.40	0.000000
8	30	10	10.7	15	10.8	−6.68	0.000000

dB to 109.7 dBA. The 5-dB exchange rate was used in our calculations because Brazilian legislation (Brasil, 1978) has set this value for the calculation of permissible exposures (with 85 dBA as maximum permissible exposure limit). If we had used the 3 dB exchange rate used by most other countries, the results would have been higher. Comparison of our results with others should take this difference in consideration. But even with the use of the 5 dB exchange rate, the observed elevated levels are similar to those of other studies conducted in nightclubs in Brazil (Gunderson et al, 1997; Vansin & Assencio-Ferreira, 2002) as well as in other countries (Tan et al, 1990; Lee, 1997; Gunderson et al, 1997; Sadhra et al, 2002; Bray et al, 2004).

In the present investigation, the purpose of the sound level measurement was to illustrate the levels in nightclubs where the studied DJs work. To study damage-risk relationships one would need to fully evaluate their music exposure, which can be quite challenging but necessary for proposing guidelines for safe working conditions. In Curitiba, where the present study took place, the DJs' work routine is extremely variable and unpredictable. It varies night by night, week by week. To do a proper exposure characterization in such circumstances would require doing dosimetry for an extensive period of time. Such time and resources were not available for this study.

The DJs' most frequent auditory complaints post-exposure were bilateral tinnitus and fullness in the ear, in agreement with other studies in DJs, users of CD or cassette players, as well as young people who frequent nightclubs and those who work there (Lee, 1997; Gunderson et al, 1997; Sadhra et al, 2002; Silveira et al, 2001; Bray et al, 2004).

We observed 11 cases (27%) of high frequency sensorineural hearing loss, despite the young age of the participants (mean age was 27 years) and their short time in the profession (mean music exposure as a DJ was 7 years), as reported in previous studies (Lee, 1997; Sisnando, 2002; Bray et al, 2004). It is possible that DJs with hearing symptoms may have been more likely to participate in the study than those without hearing difficulties (self-selection bias). For a precise estimation of the prevalence of hearing disorders among DJs, a larger investigation with different subject recruitment methods is recommended.

In the present study, temporary threshold shifts following music exposure occurred in all tested frequencies, with the largest shifts occurring at 3000, 4000, and 6000 Hz. The same has been reported following the use of CD or cassette players at high intensities (Silveira et al, 2001; Vansin & Assencio-Ferreira, 2002; Sahdra et al, 2002). Temporary threshold shift has been observed among people who worked in bars and at discotheques, with 4000 and 6000 Hz as the most affected frequencies (Andrijauskas, 2003; Kähäri et al, 2002; Marcon-Paniz, 2005).

The present study is the first to evaluate DJs with otoacoustic emissions. The results of the DPOAE testing showed a statistically significant difference pre- and post-music exposure (decreased response amplitudes following music exposure), at most test frequencies. The few exceptions could be explained by random variation.

Table 3. Number and percentage of observations of temporary threshold shift (equal or greater than 10 dB), by ear and by frequency tested

	500 Hz		*1000 Hz*		*2000 Hz*		*3000 Hz*		*4000 Hz*		*6000 Hz*		*8000 Hz*	
Ear	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Right	10	33	14	46	17	56	21	70	23	76	18	60	14	46
Left	13	43	13	43	18	60	22	73	22	73	19	63	14	46

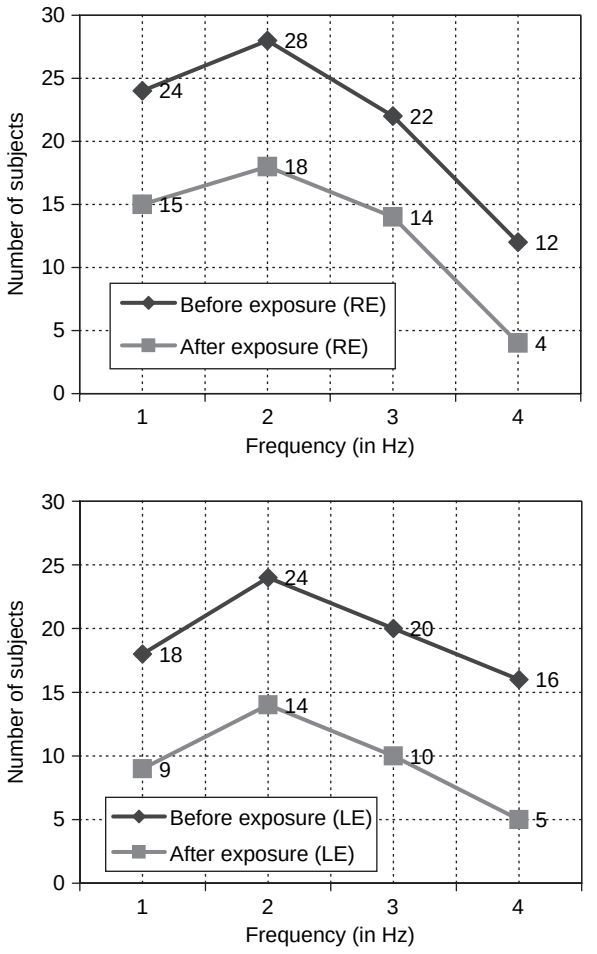

Figure 2. Number of participants with presence of TEOAEs in the different frequency bands pre- and post-music exposure (RE = right ear; LE = left ear).

Out of the 30 participants, seven individuals were found to have normal pure-tone audiometry and absent TEOAEs in the left ear, while six individuals had normal pure-tone audiometry and absent TEOAEs in the right ear, illustrating how TEOAEs can be an earlier indicator of cochlear dysfunction. The comparison of the TEOAE results showed significant differences in the SNR pre- and post-music exposure in all test frequencies in both ears, with poorer responses after music exposure. A significant decrease was observed at all frequencies in both ears in the comparison of the reproducibility of TEOAEs. These results contributed to the identification of the deleterious effect of music exposure in cochlear function, since robust TEOAE responses are only present when hearing thresholds are better than 20 dB, or the individual is not exposed to any ototraumatic factor (Kemp, 1978). Considering

Table 4. Paired t-test results for the comparison of the signal-to-noise ratio of TEOAEs, pre- and post-music exposure

Ear	*Frequency Band (Hz)*	*n**	*t*	*p*
Right	1000	28	2.66	0.0130
	2000	27	3.91	0.0005
	3000	25	4.77	0.0000
	4000	19	3.97	0.0009
Left	1000	23	3.80	0.0009
	2000	25	4.88	0.0000
	3000	25	4.78	0.0000
	4000	20	2.99	0.0075

*Number of cases in which a response was obtained.

Table 5. Comparison of paired t-test results for the reproducibility of the TEOAEs, pre- and post-exposure to music, by frequency band

Ear	*Frequency band (Hz)*	*n*	*t*	*p*
RE	1000	30	2.27	0.0301
	2000	30	3.84	0.0006
	3000	30	4.00	0.0004
	4000	30	3.65	0.0010
LE	1000	30	3.45	0.0017
	2000	30	3.94	0.0004
	3000	30	3.18	0.0035
	4000	30	3.65	0.0010

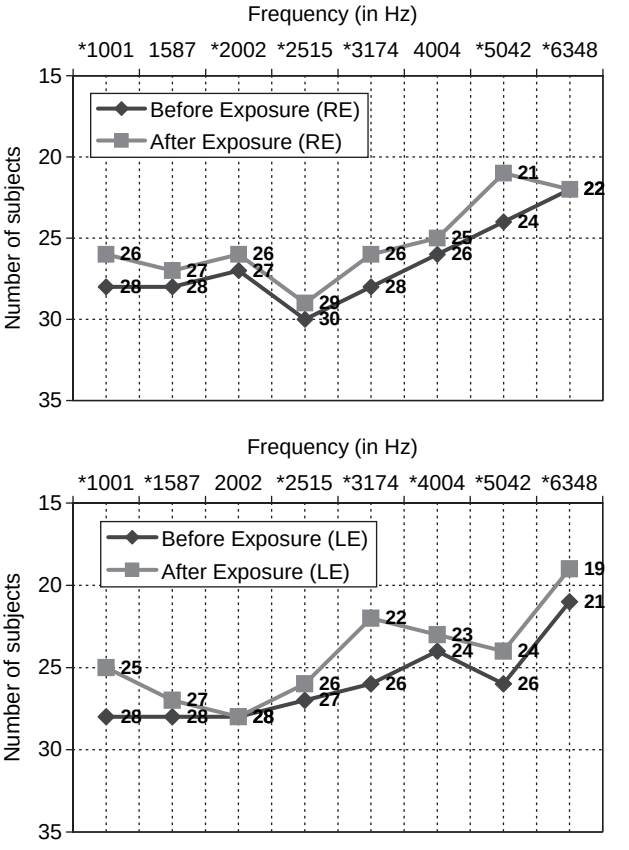

Figure 3. Number of participants with presence of a DPOE response in the different frequencies pre- and post-exposure. Right ear (RE), left ear (LE) indicates statistically significant differences.

Table 6. Paired t-test results for the comparison of absolute amplitudes of the DPOAE results pre- and post-exposure to music at work, by ear (RE = right ear; LE = left ear)

Ear	*Frequency (f2) (Hz)*	*t*	*p*
RE	1001	1.74	0.0916
	1587	1.86	0.0729
	2002	2.26	0.0311
	2515	2.36	0.0254
	3174	1.92	0.0650
	4004	1.87	0.0714
	5024	1.99	0.0564
	6348	2.19	0.0338
LE	1001	3.50	0.0015
	1587	1.72	0.0952
	2002	1.48	0.1483
	2515	2.07	0.0473
	3174	2.55	0.0163
	4004	2.09	0.0451
	5024	1.68	0.1039
	6348	2.46	0.0201

that we observed a decreased response both in the SNR as well as the reproducibility, we can conclude that their music exposure interfered with their cochlear function. Similar results of a reduction in the mean amplitude of the responses and the reproducibility of the TEOAEs after exposure to amplified music, mainly in the frequency bands of 3000 and 3700 Hz have been previously reported among rock and roll musicians (Andrijauskas, 2003).

The results of the present study showed that DJs who use the headphones on their left ear (70% of the participants) had greater pure-tone threshold shifts in that ear. However, paired t-test results revealed no statistically significant differences between the results of the left and right ears for any of the tests performed pre- or post-music exposure.

In the present study, both DPOAEs and TEOAEs indicated some auditory dysfunction after music exposure at work among DJs. These tests are known for the potential to serve as early indication of a dysfunction when audiometric results are within normal range. When we compare the DPOAE and TEOAE results obtained in this study we notice that the percentage of ears with an absence of response post-music exposure was greater in the TEOAE than in the DPOAE testing. The clinical implication of this finding is that if one needs to choose one otoacoustic emission test for evaluating the effects of music exposure with patients that are experiencing temporary threshold shifts, TEOAEs would be a good option for persons with normal or mild hearing losses. Moreover, one should take in consideration the large variability of DPOAE responses both in individuals with normal hearing as well as in individuals with hearing loss, and a decrease in amplitude can be registered following music or noise exposure, but still be present.

The DJs in this study had noticed auditory effects and learned of the study results. Still they did not see the need for any changes. Having the information about the risk and having experienced some signs of a dysfunction, has not motivated them to search for preventive alternatives. This suggests the need for some sort of public health initiative.

In Brazil, as in many other countries, the lack of legal standards for sound exposure specific to musicians can lead to the incorrect assumption that this type of work is free of auditory risks. Australia, Switzerland, Italy, Austria, Finland, and Sweden are some of the few countries that have specific recommendations for occupational exposure limits when it comes to musical activities or noise in the entertainment industry, for musicians as well as the audience. Even if some of these standards are quite similar to general recommendations for occupational noise exposure, they send a message that workers exposed to high intensity music can also be at risk, and should take precautionary measures to prevent auditory effects.

The Australian WorkSafe Department of Consumer and Employment Protection has updated a Code of Practice for the Control of Noise in the Music Entertainment Industry in 2000. They not only indicate occupational exposure limits that should be followed in this industry, but also offer guidelines for controlling music exposure (McMillan & Gunn, 2000). The Swedish Administration of Health and Occupational Safety has regulations to limit exposure to 85 dB L_{eq} for eight hours, with slow max of 115 dB(A) and 140 dB(C) as the peak level, to control the risk of hearing loss among musicians (Kähäri et al, 2003). For those who attend concerts, the Swedish National Directory of Health and Welfare established a recommendation of 100 dB L_{Aeq} and a maximum value of 115 dB(A) during a musical performance. The authors indicated that the higher value for the audience is based on evidence that music is not as damaging as industrial noise. The recommended value of 100 dB L_{Aeq} is assumed to be safe for a duration of one hour/day (or five hours/week), on the assumption that other exposure to sound does not exceed 85 dB L_{Aeq} during the rest of the week.

The present results suggest that musicians would benefit from a specific standard of hearing conservation/protection and that there is a need for dissemination of information to DJs about the risks that electronically amplified music can have on their hearing. Strategies for the prevention of hearing loss induced by music have been proposed (for details see Bogoch et al, 2005.)

In a study with 42 non-professional pop and rock musicians, Schmuziger et al (2006) have shown that the consistent use of hearing protection lessened the amount of permanent threshold shift in this population. They observed that hearing loss in the subjects who always used ear protection was only 0.9 dB higher than the control group. In contrast, hearing loss was significantly more pronounced, at 6.7 dB higher than the control group, in those musicians who never used ear protection.

Conventional earplugs offer non-uniform attenuation, resulting in sound which is unclear and distorted. Fortunately today there are alternative hearing protection products, more tailored to musicians' needs. These protectors offer almost flat attenuation, reducing sound levels uniformly across frequencies, thus preserving sound quality. Information on these devices should be made available for musicians and other professionals exposed to loud music. However, as indicated by the DJs in this study and the initial evidence from previous

investigations on the use of hearing protection among musicians (Gunderson et al, 1997; Mendes et al, 2006; Laitinen, 2005; Schmuziger et al, 2006), convincing music-exposed workers to wear hearing protection could be as challenging as convincing industrial noise-exposed workers to protect their hearing.

Conclusion

The sound pressure levels in Brazilian nightclubs are higher than the Brazilian permissible exposure limit of 85 dB (A) for eight hours. The measured sound pressure levels raise a concern for nightclub workers and DJs as well as the audience and other staff, waiters, bartenders, security personnel, and even the owners of these places.

The study revealed a significant difference in the audiometric exams conducted pre- and post-exposure to amplified music; the DJs suffered a decrease in hearing ability post their music exposure at work. Pure-tone audiometry indicated cases of hearing loss and the occurrence of temporary threshold shifts at every test frequency among the study participants. Both DPOAEs and TEOAEs indicated some auditory dysfunction post-music exposure. A reduction was observed in the amplitude of the evoked otoacoustic emissions, used in the evaluation of the outer hair cell function. These results indicate the importance of developing hearing loss prevention strategies specific to these workers.

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Disclaimer

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