Auditory effects among young musicians of a philharmonic band

Efeitos auditivos em jovens músicos de uma banda filarmônica

Efectos auditivos entre los jóvenes músicos de la banda filarmónica

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Abstract

Introduction: *Music is considered a pleasant sound. However, it can have a negative effect on people's lives.* ***Objective:*** *To identify the auditory effects of music exposure in young musicians of a philharmonic band.* ***Methods:*** *The sample was conducted with 22 musicians of a philharmonic band. The procedures include otoscopy, middle ear analysis, pure tone audiometry, Transient Evoked Otoacustic Emission (TEOAE) and Distortion Product (DPOAE).* ***Results:*** *The study included 22 male musicians, aged from 13 to 24 years old, average 17.4. The most frequent auditory complaints were intolerance to loud sounds, communication difficulties and tinnitus. All the subjects presented auditory thresholds within normal patterns. However, were observed audiometric notches in both ears. In general, the TEOAE and DPOAE were present; however, two musicians had an absence of TEOAE in the right ear in at least one of the frequency bands and, in the left ear, this fact occurred in four musicians. In the DPOAE, it was found an absence response in six musicians in, at least, one frequency in both ears.* ***Conclusion:*** *Despite the young sample and normal hearing thresholds, there was a high incidence of auditory complaints, changes of responses in otoacoustic emissions and audiometric notches.*

Keywords: *Hearing; Audiology; Music.*

Resumo

Introdução: *A música é considerada um som agradável. No entanto, pode interferir negativamente na vida das pessoas.* ***Objetivo****: Pesquisar os efeitos auditivos decorrentes da exposição à música em jovens de uma banda filarmônica.* ***Método:*** *A pesquisa foi realizada com 22 músicos de uma banda*

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Filarmônica. Os procedimentos incluíram meatoscopia, medidas de imitância acústica, audiometria tonal, emissões otoacústicas evocadas por estímulo transiente (EOAT) e produto de distorção (EOAPD). ***Resultados:*** *Participaram do estudo 22 músicos do gênero masculino, na faixa etária de 13 a 24 anos, com média de 17,4. As queixas auditivas de maior ocorrência foram o incômodo a sons fortes, dificuldade de comunicação e zumbido. Todos os indivíduos apresentaram limiares auditivos dentro dos padrões de normalidade. Entretanto, foram observados entalhes audiométricos em ambas as orelhas. No geral, as EOAT e EOAPD foram presentes, porém, dois músicos tiveram ausência de EOAET na OD em pelo menos uma das bandas de frequência e na OE esse fato ocorreu em quatro músicos. Na EOADP constatou-se ausência de emissões em seis músicos em, pelo menos uma frequência, em ambas as orelhas.* ***Conclusão:*** *Apesar da amostra jovem e dos limiares auditivos normais, observou-se alta ocorrência de queixas auditivas, alterações de respostas nas emissões otoacústicas e entalhes audiométricos.*

Palavras-chave: *Audição; Audiologia; Música.*

Resumen

Introducción: *La música se considera un sonido agradable. Sin embargo, puede tener un efecto negativo en la vida de las personas.* ***Objetivo:*** *Identificar los efectos auditivos de la exposición a la música en los jóvenes músicos de una banda filarmónica.* ***Método:*** *La muestra fue de 22 músicos de una banda filarmónica. Los procedimientos incluyen otoscopia, análisis del oído medio, audiometría de tonos puros, emisiones otoacusticas evocadas por transitorios (EOET) y productos de distorsión (EOPD).* ***Resultados:*** *El estudio incluyó a 22 músicos de sexo masculino, con edades de 13 a 24 años de edad, con media de 17,4. Las quejas auditivas más frecuentes fueron la intolerancia a sonidos fuertes, dificultades de comunicación y el tinnitus. Todos los sujetos presentaron los umbrales auditivos dentro de los patrones normales. Sin embargo, se observaron muescas audiométricas en ambos oídos. En general, el EOET y EOPD estaban presentes; sin embargo, dos músicos tenían una ausencia de EOET en el oído derecho en al menos una de las bandas de frecuencia y, en el oído izquierdo, este hecho se produjo en cuatro músicos. En el EOPD, se encontró una ausencia en seis músicos en, al menos, una frecuencia en ambos oídos.* ***Conclusión:*** *A pesar de la juventud de la muestra y los umbrales de audición normales, hubo una alta incidencia de quejas auditivas, los cambios de las respuestas de las emisiones otoacústicas y muescas audiométricas.*

Palabras claves: *Audición; Audiología; Música.*

Introduction

Music is an important part of people's lives and can connect them. It is generally considered a pleasant sound that evokes memories of facts or important events of our lives. However, continuous exposure to high levels of music may have a negative impact on people's lives[1].

Many health professionals have focused on studies where subjects are systematically exposed to music not merely for leisure activities, but rather as a result of their occupational activities [2].

Musicians are at systematic exposure to high sound pressure levels. They practice and play their instruments for many hours in individual and collective rehearsals, and usually deliver a high number of musical performances. Thus, it can be affirmed that these professionals are a group at risk for development of occupational hearing loss [3-5].

Despite the conceptual difference between noise and music, systematic exposure to these stimuli may result in similar audiometric configurations, such as the occurrence of notches at frequencies in the range of 3 kHz - 6 kHz and progression of hearing loss depending on the time of exposure [6,7].

In addition to auditory effects such as tinnitus and intolerance to loud sounds, other disorders may affect the physical and mental wellbeing of these individuals, namely: insomnia, stress and memory problems [8].

The consequences of exposure to high sound pressure levels faced by professional musicians are relevant and widely discussed. However, few studies with young musicians or music students that might contribute to early diagnosis of possible

hearing disorders and the consequent adoption of preventive measures were conducted. Therefore, the present study aimed to investigate the effects of sound exposure to hearing in young musicians of a local Philharmonic Orchestra.

Methods

Observational and cross-sectional survey approved by the Research Ethics Committee of Pontifícia Universidade Católica of São Paulo, under no 784.024. The study procedures were explained verbally to participants, and those who agreed to participate, or their guardians, signed the free informed consent.

The sample was composed of performers from a local band in the city of Lagarto, state of Sergipe. This band provides the training of young musicians based on musical lessons that include music theory and practice. The musicians deliver presentations throughout the state in cultural activities, such as band gatherings.

The inclusion criteria were frequent attendance to rehearsals, i.e., at least three times a week, during two hours, as well as being practicing the musical instrument for at least six months.

In total, 29 musicians were invited to participate in the study. Of these, 22 musicians aged 13-24 years agreed to participate and attended the clinic of audiology of Universidade Federal de Sergipe, campus Lagarto, for the procedures. The subjects played the following instruments: saxophone, percussion, clarinet, tuba, trumpet, drums, trombone and French horn.

Anamnesis was conducted to obtain data relate to the individual's history in the band, general health data and hearing complaints, including self-perception of hearing ability and discomfort with loud sounds. After anamnesis, pure tone audiometry was performed. For this purpose, Interacoustics audiometer, model AD229 was used, and the test was performed in acoustic booth, in accordance with the terms established by Regulatory Standard no 7, of Brazil's Ministry of Labor and Employment [9]. According to the referred standard, audiograms with hearing thresholds lower than or equal to 25 dB (NA), at all the frequencies assessed were considered within normal limits. Normal audiograms were also classified according to the occurrence of notch at frequencies in the ranges of 3 kHz, 4 kHz and 6 kHz. Audiometric notches occurred when for 3 kHz and/or 4 kHz and/or 6 kHz frequencies/thresholds there was a difference of at least 10 dB compared to the previous or subsequent frequencies[10].

Tests of Transient-evoked Otoacustic Emissions (TEOAE) and of Distortion-product Otoacustic Emissions (DPOAE) were performed with Otoport DP+TE equipment of brand Otodynamics. Prior to these tests, otoscopy and acoustic immitance tests were conducted to determine any possible middle ear disorders, since these may influence the results of OAE's tests.

In TEOAE, a probe was used to present the click stimulus covering a frequency range from 500 Hz to 4 kHz, producing a wide range of stimuli. An average of 260 stimuli was used, with 80 dBSPL. Responses at frequency ranges of 1,000, 1,500, 2,000, 3,000 and 4,000 Hz were investigated. The criterion used for analysis of presence was a response in dBSPL, greater than or equal to 3 dB NPS, in each frequency range tested [11].

The DPOAEs are evoked by simultaneous presentation of two pure tones of different frequencies (f1 and f2). There is a precise mathematical relationship between the two tones, which is 2f1-f2. The tones are mixed in the probe before it is centered at the external acoustic meatus of the subject, according to the mathematical ratio of 1.22. The level of each stimulus is known as L1 (of frequency f1) and L2 (of frequency f2), and in the present study 65 dBSPL and 55 dBSPL were used, respectively. The criterion used to indicate the presence of DPOAEs was a response in dBSPL at least 6 dB above the first standard deviation of the equivalent noise, at each f2 tested[12].

In both OAE tests, in addition to general analysis, distributions of response percentile levels (quartiles) and analysis of response presence were also assessed. Descriptive analysis of variable "response" (in dBSPL) was performed by frequency range (in Hz) for transient-evoked OAE, and by f2 value (in Hz), for DPOAE, for each ear. At first, percentiles of this variable were obtained and then variable SNR (in dBSPL) was classified for each ear, frequency range and f2 value, as follows:

- TEOAE (per frequency range): < 3.0 (absent) and ≥ 3.0 (present)
- DPOAE (per f2): < 6.0 (absent) and ≥ 6.0 (present)

After descriptive statistics of the data, the outcome variable selected was complaint *"discomfort*

with loud sounds" to detect possible associations (Chi-square test of independence) with the other variables of the database. The responses were dichotomized as follows: The categories "Nothing" and "Very Little" were converted into a new category "Little", while categories "More or Less" and "A lot" were converted into a new category "Much".

Besides, a logistic regression model was adjusted for the response variable ("discomfort with loud sounds"), including the possible explanatory (dependent) variables. In order to verify how well the logistic regression model fit the data, C statistics of Hosmer-Lemeshow goodness test was calculated.

C value was 0.81. The P value associated to C statistics was 0.668 (> 5%). This value indicates that the logistic regression model was well-fitting.

The level of significance adopted in each test was equal to 5%.

Results

In total, 22 musicians participated in the study: 72.73% men and 27.27% women. The average age was 17.41 years (±3.20), median of 17.0, ranging from 13 (minimum) and 24 (maximum) years. Regarding how long the musicians have been playing a musical instrument, the average time was 59.09 months and median of 66.5, with a minimum period of 12 and maximum period of 141 months. As for the experience of the band, the average time was 50.77 months, median of 48.0, with a minimum of 6 and maximum of 141 months.

In addition to the Philharmonic Orchestra of the city of Lagarto/SE, 63.64% (n=14) of youngsters participate in other bands. The most played instruments were Saxophone and Clarinet (22.73% for both), followed by Trumpet (18.18%), Percussion (13.64%), Drums (9.09%), Tuba, Trombone and French horn (all of them with 4.55%).

Concerning hearing complaints, most respondents (n= 13 – 59.09%) reported discomfort with loud sounds followed by tinnitus (n= 8 – 36.36%), dizziness and headache (n= 7 – 31.82% for both). Only six (27.27%) musicians reported a feeling of ear fullness.

Regarding self-perception of hearing ability, 11 (50%) reported not suspecting of any hearing disorders, while six of them (27.27%) reported hearing impairment and five (22.73%) were unable to report their perception in this regard. Most individuals (n=14; 63.64%) reported that their hearing ability was not affected by their participation in the band, remaining unchanged. However, 36.36% (n=8) reported worsening of hearing in one or two ears after they joined the band.

Regarding the impact of ambient noise on communication during rehearsals and performances, the responses were distributed as follows: nothing (n= 1 – 4.55%), very little (n= 8 – 36.36%), more or less (n= 6 – 27.27%) and a lot (n= 7 – 31.82%).

Pure-tone audiometry results indicated that thresholds in the frequencies of 250 Hz and 8 kHz were within normal limits in both ears for all the musicians. However, some youngsters had notches in at least one of the frequencies between 3 kHz and 6 kHz, in at least one of the ears. Five notches were observed in the right ear (22.72%), with three in the frequency of 6 kHz and two in the frequency of 4 kHz. In the left ear, eight (36.36%) notches were observed, as follows: five in the frequency of 4 kHz, two at 3 kHz and one at 6 kHz.

Distribution of response percentile levels (in quartiles) of TEOAE indicated better response levels in the frequency ranges of 1000, 2000 and 3000 Hz in both ears. (Tables 1 and 2). Regarding the DPOAE, it was found that the f2 with worse response levels was frequency 8 kHz, particularly in the right ear (Tables 3 and 4).

Table 1. Percentiles (quartiles 25, 50 and 75) of the response variable (in dB SPL) by frequency band (in Hz) for the right ear – TEOAE.

Frequency band in Hz	n	Minimum	P25	P50	P75	Maximum
1000	22	-12,60	-8,38	-1,95	3,50	9,80
1500	22	-3,10	2,67	7,35	10,10	18,20
2000	22	-4,80	4,80	7,70	9,42	13,80
3000	22	-3,00	2,45	5,60	10,13	14,30
4000	22	-14,40	-2,70	1,00	4,50	16,90

Table 2. Percentiles (quartiles 25, 50 and 75) of the response variable (in dB SPL) by frequency band (in Hz) for the left ear – TEOAE.

Frequency band in Hz	n	Minimum	P25	P50	P75	Maximum
1000	22	-15,00	-10,08	-6,15	2,90	5,50
1500	22	-4,60	2,60	5,45	10,85	15,60
2000	22	-5,90	0,78	4,15	7,90	15,50
3000	22	-8,80	2,75	7,20	9,45	18,10
4000	22	-13,80	-3,77	1,00	4,83	12,90

Table 3. Percentiles (quartiles 25, 50 and 75) of the response variable (in dB SPL) by f2 (in Hz) for the right ear – DPOAE

f2	n	Minimum	P25	P50	P75	Maximum
1500	22	-11,30	6,40	13,80	18,50	20,60
2000	22	-31,90	4,15	11,50	16,18	19,50
3000	22	-7,60	2,75	7,50	10,65	18,50
4000	22	-6,50	5,83	8,40	13,28	21,50
6000	22	-13,00	7,05	11,95	14,53	19,80
8000	22	-31,30	-2,72	1,15	4,00	14,40

Table 4. Percentiles (quartiles 25, 50 and 75) of the response variable (in dB SPL) by f2 (in Hz) for the left ear – DPOAE.

f2	n	Minimum	P25	P50	P75	Maximum
1500	22	-10,70	3,50	11,15	16,73	25,30
2000	22	-22,90	2,55	6,95	12,88	18,90
3000	22	-9,60	-1,18	3,70	7,15	18,60
4000	22	-8,80	1,58	8,55	11,97	26,10
6000	22	-19,70	2,17	9,90	14,35	23,00
8000	22	-20,70	-2,13	2,30	6,15	13,90

Analysis of transient-evoked otoacoustic emissions showed that for two musicians (9.09%) was absent in the right ear, in at least one of the frequency ranges. In the left ear, in turn, it was absent in four musicians (18.18%). Of these, TEOAE was absent in three in the frequency range of 4 kHz. DPOAE tests showed absence of emissions in six musicians (27.27%) in at least one frequency in both ears.

The outcome variable selected for inferential statistics was "Discomfort with hearing loud sounds", since this was the most common complaint in the study sample (n= 13, 59.09%).

Chi-square tests for association showed evidence of association only between the variables "Discomfort with hearing loud sounds" and "Noise interference with verbal communication" (p= 0.041). Therefore, the percentage of individuals that felt discomfort with hearing loud sounds is higher among those who believe ambient noise interferes with their verbal communication (76.92%) compared to those who do not have the same perception (33.33%). Subsequently, a logistic regression model was adjusted to represent the odds ratio and their 95% confidence interval (CI).

Interpretation of the odds ratio indicated that when ambient noise hampers communication with others, the chance of someone being bothered by loud sounds was 6.7% greater than the chance of not being bothered.

Table 5. Estimates, standard error, p value, odds ratio and confidence interval (95%) of the logistic regression.

Parameter	Estimative	Standard Error	Value p	Odds ratio	CI(95%) Odds ratio	
					Inferior Limit	Upper Limit
Intercept	-0,693	0,707				
interference with communication	1,897	0,966	0,039	6,6667	1,0036	44,2840

In order to verify how well the logistic regression model feels the data C statistics of Hosmer-Lemeshow goodness test was calculated (Hosmer et Lemeshow, 2000). C value was equal to 0.81. The p value associated to C statistics was equal to 0.668 (> 5%). This value indicated that the logistic regression model was a well-fitting model.

Discussion

Most musicians that composed the sample were men (72.73%). Such gender prevalence was found in many studies with musicians [13,14]. However, regarding age, it was in average 17.41 years (±3.20), slightly lower than the one reported by the referred authors.

The respondents have been playing musical instruments in average for five years. Nevertheless, despite their young age, some of these musicians have been systematically exposed to music for around 12 years. Length of exposure is one factor related to hearing losses, and consequently, may be occurring in music bands formed by young musicians or in groups of music students [15,16]. Thus, the development of preventive campaigns and early interventions is essential to prevent possible damage to the health of these individuals [1,15,16]. Most musicians who participated in this study also integrate music bands in other cities. This fact was also observed in another study[17], where many respondents participated in other groups of musicians or in professional and/or leisure activities that involved significant exposure to noise. Such situations, as well as the additional individual rehearsals increase the daily amount of time of exposure to amplified music and contribute to the occurrence of complaints of health problems and hearing impairment[18,19].

Several studies with musicians of different music genres, even at different age groups, indicated tinnitus (39% to 50%) and intolerance to loud sounds (19% to 58.8%) as the main complaints arising from exposure to music [4,8,17,19,20]. Such data corroborate the results of the present study that also identified tinnitus (36.36%) and discomfort with loud sounds (59.09%) as the main complaints.

A study on tinnitus in teenagers showed no evidence of disorders in audiometric tests and otoacoustic emission testing. However, decrease in the threshold of discomfort with loud sounds was observed in youngsters experiencing constant tinnitus, which may suggest vulnerability to sounds, as well as increased risk for hearing loss in the future[21]. Clarifications about tinnitus are relevant since this is a frequent hearing symptom, not only among musicians, and tends to increase as a result of exposure to noise and also with increased longevity and chronic comorbidities[22].

There was an association between the variables: “Discomfort with loud sounds” and “Noise interference with oral communication”. Moreover, the results obtained indicated that when ambient noise interferes with communication, the individual is more likely to feel discomfort with loud sounds. This response was also described in a study with workers of commercial establishments whose reports demonstrated the interference of high sound pressure levels on their activities, particularly in verbal communication and concentration[23].

Ineffective communication in noisy environments is also a common complaint in scientific research [20,23]. Although musical experience provides benefits related to auditory perception, such training does not always influence the ability to orally communicating in a noisy environment[24]. The environment where musical rehearsals and presentations take place has high noise levels and verbal communication difficulties can be one of the main complaints reported by musicians[13].

Regarding self-perception, half of the respondents believe they do not suffer from hearing loss, although audiometric tests did not detect hearing loss in any of them. Also, some of respondents reported loss of their ability to hear from one or two ears (36.36%). Self-perception of loss or complaint of not hearing well is an important indicator in hearing assessment, particularly in individuals exposed to noise. Although the present sample is composed by youngsters with normal thresholds of hearing, some musicians are not aware of any hearing loss or believe they do not have any hearing loss. In another study, complaint of hearing difficulties occurred in individuals who have been exposed to loud sounds from one to 10 years. However, hearing loss tends to increase with exposure to noise over time[18].

Normal thresholds of hearing were observed in all the individuals who composed the study sample, in contrast with the findings of many other studies with musicians [4,8,13,25]. This can be explained by the age group of the individuals and, in some cases, by the short-term (in number of years) exposure to noise. Other studies conducted with young musicians indicated that all, or most of them, had normal thresholds of hearing [14,15,20].

Other factors can be related to the results of audiological testing of the musicians, namely: detection by pure tone audiometry was possibly easier for this sample, genetics and individual susceptibility. Moreover, several authors also reported that further studies with larger samples are needed [26-28].

Even though the results of audiological tests were within normal limits, some audiometric notches were observed. This may be an indication that exposure to high sound pressure levels may generate lower thresholds over time and hence result in hearing losses. Some studies with musicians also reported the occurrence of notches in individuals with normal audiometric thresholds [8,27].

Although none of the musicians that participated in this study had any hearing loss, there were many complaints related to hearing ability, such as discomfort with loud sounds, verbal communication difficulty and tinnitus. One study with 63 musicians from five classical orchestras of Finland found that the hearing impairment observed was consistent with that observed in the general population. However, when the musicians were divided into groups of subjects more and less exposed to high noise levels, the most exposed subjects had much worse audiometric thresholds in the frequency of 3 kHz. Despite the fact that the hearing losses observed in the sample were within normal standards, many subjects complained of tinnitus, corroborating other studies that identified the harmful effects of high sound pressure levels to health[28].

OAE testing showed few abnormalities, in contrast with other studies with musicians [4,13]. However, this finding corroborates one study according to which this fact is explained by the short-term exposure to noise [29]. The subjects in the referred study were not subjected to a routine that involved attendance to many rehearsals and exclusive dedication to music and were also in average young individuals, which may explain the non-occurrence of many OAE abnormalities, since increased age influences responses[30].

However, although these are young individuals with normal hearing thresholds, in analysis of TEOAE in each ear absence in at least one of the frequency ranges was 9.09% in the right ear and 18.18% in the left ear. Regarding DPOAE, absence in at least one f2 was 27.27% in both ears. Other studies also identified disorders in OAE, particularly in the higher frequencies, even in musicians without hearing impairment [8,27].

The results of the present study indicate the importance of otoacoustic emission testing as an epidemiological surveillance tool, particularly to identify evidence of disorders resulting from continuous exposure to amplified music. However, analysis of frequency ranges, in the case of TEOAE and DPOAE are key to identify early disorders. Therefore, analysis of responses according to distribution of percentile levels is recommended rather than the mere use of criteria that establish the dichotomy of "present" and "absent" test. We also report the need for further studies using paired samples.

The present study identified significant hearing complaints despite the young age of the subjects and their short-term exposure to noise. Thus, the importance of conducting studies which in addition to identifying health problems in musicians also contribute to the planning of interventions targeted to health protection and prevention of the harmful effects caused by exposure to risks is evident.

Conclusion

Despite the young age of the musicians who composed the sample of this study, hearing complaints such as tinnitus and discomfort with loud sounds were very common. Noise is a factor that makes verbal communication difficult and increases the risk for musicians to experience discomfort at hearing loud sounds. In addition, the presence of audiometric notches and some alterations in the responses of evoked otoacoustic emissions, even when audiometric thresholds are normal, suggests increased risk for hearing impairment among these individuals in the future.

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