Hearing of professional violinists: cochlear function and auditory symmetry study

Audição de violinistas profissionais: estudo da função coclear e da simetria auditiva

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ABSTRACT

Purpose: To verify the occurrence of hearing disorders in violinists and if there is an association with the more exposed ear. **Methods:** Subjects were ten violinists, eight female and two male, with ages between 17 and 69, who constituted the Study Group. They were matched according to age and gender with non-musicians with no hearing complaints. Subjects were assessed by pure tone audiometry, speech audiometry, acoustic immitance measures, transient evoked otoacoustic emissions, and distortion product otoacoustic emissions, preceded by otoscopy and anamnesis. The exclusion criterion was altered tympanometry. **Results:** There was higher occurrence of bilateral tinnitus in the Study Group. It was observed that musicians do not use hearing protector during training and presentations. In pure tone audiometry, there was no difference between thresholds obtained for both groups. It was found higher occurrence of hearing disorders in the left ear, but this difference was not significant. In the transient evoked otoacoustic emission and distortion product otoacoustic emission, there was also no difference between groups, neither in the comparison between ears. **Conclusion:** It was observed higher occurrence of hearing disorders in the group of violinists, with higher percentage of alterations in the left ear. However, the difference between right and left ears was not significant.

Keywords: Hearing; Otoacoustic emissions, spontaneous; Music; Hearing loss; Noise, occupational

INTRODUCTION

Although music is a pleasant sound, it can become a major threat to human hearing when it is played at high intensity[1].

To ensure a pleasant instrumental performance, musicians need to undertake many hours of individual and group practice. Added to this is the high frequency of presentations, subjecting them to constant exposure to high sound pressure levels, which can cause permanent hearing damage[2].

Although the association between noise exposure and occupational hearing loss has already been described for more than a century, it was not until the 1960s that some researchers began to turn their attention to the effects of music on hearing[3,4].

Many studies point out to the potential risk of hearing loss induced by music, among the many different styles of musical composition and performance. Given this fact, it can be said that musicians are a group likely to develop hearing loss of occupational origin[5].

Many studies have shown the occurrence of Music-Induced Hearing Loss (MIHL), but musicians are often not aware of the risks that accompany exposure to very loud music. Hearing loss is irreversible and can affect the performance of musicians. Their perception of sound characteristics such as tones and timbres, for example, may be impaired, with greater or lesser relevance, by any degree of hearing loss, which could impair their professional activities[6].

The sound of the violin is the result of the waveform originated from the excitation of the strings (made of steel) by the bow (made of about 200 strands of horsehair), coming from the vibrations and resonances of the body of the instrument, its plates and bridge. When the bow is drawn over the strings at a speed of approximately 0.5 m/s, a listener three meters away from the instrument perceives a sound of 76 dBHL. The violin strings are tuned in successive fifths, which are: Sol (G) 196 Hz, Re (D) 293.66 Hz, La (A) 440 Hz, and Mi (E) 659.26 Hz[7].

For musicians like violinists, there is a higher sound exposure in the left ear, and there may be greater alterations in the hearing on this side[8].

Recently, the otoacoustic emissions (OAE) have helped to

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check the cochlear function, contributing with the conventional audiologic evaluation to provide information about the peripheral portion of the hearing system. The advantage of the OAE would be in identifying the cochlear dysfunction before the aggravation of the injury. This test has great clinical importance because it is a direct and noninvasive means of analyzing the cochlea. The majority of peripheral hearing losses, as well as the hereditary and noise-induced losses have damaged outer hair cells, which are present in the cochlea[9].

Given what has been presented, this study had the aim to verify the occurrence of hearing disorders in violinists, and if there is an association with the more exposed ear.

METHODS

This study is characterized as a clinical cross-sectional study and it is linked to the Clinical Audiology Department of the Universidade Federal de São Paulo (UNIFESP). This research was approved by the Research Ethics Committee of the institution – protocol number 1878/09.

Participants in this study were contacted by the evaluator and showed their willingness to participate in the research by signing a Free and Informed Consent Term.

We evaluated 20 individuals. Ten of them, eight female and two male, had been active musicians for at least two years in orchestras, musical bands, music schools, or churches, with ages ranging from 17 to 69 years; they composed the Study Group, and were matched by gender and age (with a difference of up to one year) to non-musicians with no hearing complaints, who constituted the Control Group.

Initially, it was carried out a visual inspection of the external acoustic meatus using a Welch Allyn® otoscope to ensure there was no obstruction that would not allow the audiological evaluation procedures to be carried out. None of the subjects showed any kind of impediment to the realization of the subsequent procedures of this research.

After this, it was conducted an interview (anamnesis), in order to gather personal and professional information, possible hearing complaints, information regarding habits, diseases, use of medication, family history and other issues concerning the individual's hearing.

The audiological tests used to evaluate the subjects were: pure tone audiometry, speech audiometry, acoustic immitance measures, transient evoked otoacoustic emissions (TEOAE), and distortion product otoacoustic emissions (DPOAE).

In pure tone audiometry, the 250 Hz to 8 kHz thresholds were tested in a soundproof booth, with TDH39 headphones, MA-41 audiometer. Thresholds survey was conducted using the ascending-descending technique[10], considering thresholds equal to or less than 25 dB at all frequencies within the normal standards.

The speech audiometry was performed using a list of phonetically balanced monosyllabic and/or disyllabic words to determine the threshold of speech intelligibility, based on the average frequency of 500 Hz, 1 and 2 kHz. We used the same equipment described above for this test.

The acoustic immitance measures included tympanometry, using a probe tone of 226 Hz, and contralateral acoustic reflex survey for 500 Hz, 1, 2 and 4 kHz frequencies, using the AT 235 Interacoustic® impedance audiometer.

We used the classification proposed by Jerger[11] for the interpretation of tympanometric curves and acoustic reflex threshold results.

For the transient evoked otoacoustic emissions survey, a cochlear otoacoustic emissions analyzer ILO292 was used, in a soundproof booth, connected to a microcomputer. This equipment has a probe, whose function is to release the sound stimulus, receiving and measuring the response in the external acoustic meatus. This probe is connected to two channels and an interface coupled to the computer.

The test started by checking the adjustment of the probe in the external acoustic meatus and by adjusting the characteristics of the sound stimulus. We used non-linear clicks with regular pulses of 80 milliseconds of duration, with rarefied polarity, presented in a series of 260 cycles per second, within a 20 ms window. The emission spectrum of the standard stimulus contains energy distributed between 500 Hz and 5 kHz.

A response was considered present when there were emissions 3 dB above the noise in the frequency bands from 1 up 4 kHz, with reproducibility above 70%[12] and probe stability higher than 70%[13].

For the distortion product evoked otoacoustic emission, the equipment requires components similar to those described above, but with two stimulus generators. By the application of two pure tone signals of different frequencies, the cochlea causes intermodulation of the signals, producing frequency components in the output signal that were not present in the original signal[14].

The presence of distortion product depends essentially on the background noise, the equipment and the outer hair cells activity[15]. The criterion considered as response was noise level less than zero and signal/noise ratio greater than 6 dBSPL (Sound Pressure Level)[16] at frequencies from 2 up 6 kHz.

Statistical method

For the statistical analysis, an initial descriptive analysis was made using two quantitative variables: time spent practicing the instrument and weekly sound exposure time. We present average, median, standard deviation, coefficient of variation, minimum and maximum values, 1st and 3rd quartiles and confidence interval.

In order to compare the Study and Control groups regarding tinnitus, audiometry, TEOAE, and DPOAE distribution, we used the Equality of Two Proportions Test, a nonparametric test that verifies if the proportion of two variables responses and/or their levels are significant. These comparisons were made in both ears separately and then together (considering 20 pieces of information).

This study was set to a significance level of 0.05 (5%) and confidence intervals were constructed with 95% statistical confidence.

RESULTS

The average values (median and mean) regarding the time

spent practicing the instrument and weekly sound exposure time of the Study Group are presented in Table 1.

Table 1. Average values of time spent practicing the instrument (in years) and weekly sound exposure time (in hours)

	Time spent practicing the instrument (in years)	Weekly sound exposure time (in hours)
Mean	8.8	15.2
Median	7.5	15.0
SD	5.1	8.8
CV (%)	58	58
Q1	5.5	7.8
Q3	11.5	22.6
Min.	2.0	4.0
Max.	20.0	27.0
n	10	10
CI	3.2	5.5

Note: CV = coefficient of variation; Q1 = 1st quartile; Q3 = 3rd quartile; CI = confidence interval; SD = standard deviation

The comparison between Study and Control groups as to the presence of unilateral and bilateral tinnitus is presented in Table 2. The result of statistical analysis, performed through the Equality of Two Proportions test, appears on the right side of the table (p-value).

Table 2. Occurrence of tinnitus in the Study and Control groups

Tinnitus		Control		Study		p-value
		n	%	n	%	
RE	No	10	100	8	80	0.136
	Yes	0	0	2	20	
LE	No	10	100	7	70	0.060#
	Yes	0	0	3	30	
Both	No	20	100	15	75	0.017*
	Yes	0	0	5	25	

* Significant values (p≤0.05) – Equality of Two Proportions test
# Values near the significance level (up 5% above the significance level adopted)
Note: RE = right ear; LE = left ear

The results show that there was a higher incidence of bilateral tinnitus in the group of violinists than in the Control Group, and a tendency for higher incidence of unilateral tinnitus in the left ear.

The occurrence of tinnitus in the right and left ears is shown in Table 3. Comparisons are made for each group separately.

The results show that there was a higher occurrence of tinnitus in the left ear in individuals of the Study Group. However, this difference cannot be considered significant.

Regarding the use of hearing protection device in the Study Group, the results show that 100% of violinists said they did not use hearing protection during their professional activities.

Comparing the Study and Control groups on the pure tone audiometry, uni- and bilaterally, the results show a higher incidence of hearing alterations among individuals of the Study Group but without significant difference.

Table 3. Comparison between ears per group in the distribution of tinnitus

Tinnitus		RE		LE		p-value
		n	%	n	%	
Control	No	10	100	10	100	-
	Yes	0	0	0	0	
Study	No	8	80	7	70	0.606
	Yes	2	20	3	30	

Note: RE = right ear; LE = left ear

Comparing the right and left ears on the distribution of pure tone audiometry, per group, the results show differences between the ears only in individuals of the Study Group, with a higher incidence of hearing changes in the left ear. However, the difference was not significant.

The results of the comparison between the Study and Control groups for the incidence of TEOAE, uni- and bilaterally, show a higher occurrence of changes in individuals of the Study Group, with, however, no statistical difference.

The occurrence of TEOAE comparing the right and left ears is shown in Table 4, and comparisons were performed for each group separately.

Table 4. Comparison between ears per group in the distribution of transient evoked otoacoustic emissions

TEOAE		RE		LE		p-value
		n	%	n	%	
Control	Absent	1	10	1	10	1.000
	Present	9	90	9	90	
Study	Absent	1	10	2	20	0.531
	Present	9	90	8	80	

Note: RE = right ear; LE = left ear; TEOAE = transient evoked otoacustic emissions

According to these results, there was a higher incidence of hearing changes in the left ear only in individuals of the Study Group. However, there was no statistical difference.

Comparing the Study and Control groups for the incidence of DPOAE, the results show that there was a higher occurrence of changes in individuals of the Study Group, however with no statistical difference.

The comparison between the right and left ears is shown in Table 5 for the distribution of distortion product evoked otoacoustic emissions, and the comparisons were made for each group separately.

Table 5. Comparison between ears per group in the distribution of distortion product otoacoustic emissions

DPOAE		RE		LE		p-value
		n	%	n	%	
Control	Absent	1	10	1	10	1.000
	Present	9	90	9	90	
Study	Absent	1	10	3	30	0.264
	Present	9	90	7	70	

Note: RE = right ear; LE = left ear; DPOAE = distortion product otoacustic emissions

As the results show, there was a higher incidence of hearing changes in the left ear only in subjects of the Study Group. However, there was no statistical difference.

DISCUSSION

The present study addressed the issue of the exposure of the individuals to music during their professional activity, not raising data regarding their exposure to music through the use of personal electronic devices with headphones or noise present in other occupations.

The descriptive analysis of the results shows the time of exposure to noise, for the violinists, within acceptable limits, with a mean of 15.2 ± 5.5 hours per week and 8.8 ± 3.2 years of mean practice time of the instrument. It is a difficulty to estimate the risk of occupational hearing loss in musicians, due to the intermittence of their time exposure to sound, in addition to the large variation in sound pressure level[3]. Some authors have made measurements of sound pressure level in a orchestra, noting that the violins reached a mean value of 85.4 dB(A)[3]. Other authors[17], after measuring the noise level of the violin, have verified intensities of 85 dB(A). Noise with such intensity or higher than this would be harmful to hearing, and the worker should not be exposed to it for more than eight hours a day[18]. Therefore, in this study, the mean practice time of instrument did not reach sound levels harmful to hearing. In fact, other authors reported that several hours of daily exposure to noise would be necessary on the part of musicians to result in hearing loss[2].

On the other hand, there was a higher occurrence of tinnitus among the group of violinists. This result agrees with that of another study[2], which has found tinnitus as a primary complaint of musicians of the Municipal Symphony Orchestra of São Paulo. In fact, tinnitus was mentioned as one of the effects of excessive exposure to music at high intensity, in a guidebook about the risks and solutions related to noise exposure in orchestras[17].

In the present study, none of the violinists reported using personal protective equipment, and this datum is in accordance with some studies, in which the authors have observed that the use of hearing protection is generally not well accepted by musicians[3]. Other authors, in a study about the acceptance of the use of personal protective equipment by musicians, observed that after a trial period using hearing protectors, 56.2% of individuals reported dissatisfaction with the use of the equipment, for they could not hear their instrument well, had difficulty hearing the other musicians, and felt uncomfortable. Such complaints could be minimized by the use of insert hearing protectors made especially for musicians, which reduce the sound evenly, allowing the balance of attenuation of all frequencies and avoids distortion[19]. Some authors commented that, in orchestras, the difficulty of using individual hearing protection would be in the need to hear his or her own instrument and that of the colleagues. Moreover, when there is change in the musical dynamics, musicians could find it more difficult to hear musical passages in lower intensity and also to hear the maestro during the rehearsals if they were using hearing protectors[17].

Despite all these implications, there is a need for hearing protection also for individual rehearsals, because the sound pressure level to which musicians are exposed in this situation is as intense as that found in group presentations or rehearsals for orchestra musicians and choir singers[20].

The results of this study showed no difference regarding the presence of hearing changes, both with respect to the hearing thresholds in pure tone audiometry and in the results of evoked otoacoustic emissions (TEOAE and DPOAE) between groups nor between right and left ears, probably due to the time of noise exposure on the part of the musicians, which is within acceptable limits and is not considered harmful to the hearing. In fact, other authors[2] noted that the tests may show normal results even when individuals have a complaint, as is the case of this study in relation to tinnitus on the part of the violinists. In addition, normal hearing thresholds in pure tone audiometry, in patients with tinnitus, is not a determining factor in excluding the possibility of cochlear impairment[21]. These individuals have a great chance to develop hearing loss after a few years. In an earlier study, 44.5% of the subjects with tinnitus and normal audiometry developed hearing loss after 3.5 years in average. In the authors' opinion, individuals who have tinnitus should have their hearing monitored, because it may be an early warning of hearing dysfunction[22].

Finally, given the results of this study and the comments presented above, we can affirm the importance of the continuity of studies related to the hearing of violinists, as well as conducting periodic monitoring of the hearing of these professionals, given the higher percentage of occurrence of hearing changes in the Study Group when compared to the Control Group, coupled with the fact that none of the subjects in this study reported using hearing protection during his or her activity as a musician, corroborating data from other studies[3,17,19,20], which makes them more vulnerable. It is also suggested that studies should be undertaken with larger sample size, something not possible in the present study due to the great difficulty in finding individuals prepared to participate.

CONCLUSION

Through this study, we can observe a greater incidence of hearing alterations in the group of violinists, and a higher percentage of alterations in the left ear, the one with higher noise exposure, but the difference is not significant.

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RESUMO

Objetivo: Verificar ocorrência de alterações auditivas em violinistas e se há associação com a orelha mais exposta. **Métodos:** Foram avaliados dez violinistas, oito do gênero feminino e dois do gênero masculino, de 17 a 69 anos, que constituíram o Grupo Estudo e foram pareados segundo gênero e idade com não-músicos, sem queixas auditivas. Avaliações realizadas por audiometria tonal liminar, logoaudiometria, imitanciometria, emissões otoacústicas evocadas por estímulo transiente e emissões otoacústicas evocadas por produto de distorção, precedidos por meatoscopia e anamnese. Critério de exclusão: curva timpanométrica alterada. **Resultados:** Houve maior ocorrência de zumbido bilateral no Grupo Estudo. Quanto ao uso de protetor auricular, observou-se que os músicos não utilizam proteção nos treinos e apresentações. Na audiometria tonal liminar, não houve diferença entre os limiares obtidos nos grupos. Apesar da maior ocorrência de alterações auditivas na orelha esquerda, as diferenças não foram significativas. Na pesquisa das emissões otoacústicas evocadas por estímulo transiente e emissões otoacústicas evocadas por produto de distorção, também não houve diferença entre os grupos e na comparação entre as orelhas. **Conclusão:** Foi observada maior ocorrência de alterações auditivas no grupo de violinistas, com maior percentual de alterações na orelha esquerda. No entanto, a diferença entre as orelhas direita e esquerda não foi significativa.

Descritores: Audição; Emissões otoacústicas espontâneas; Música; Perda auditiva; Ruído ocupacional

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