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Biosafety materials in audiological basic assessment: comparative study between the use of disposable earphone protector and the use of polyvinyl chloride (PVC)

Recursos de biossegurança na avaliação audiológica básica: estudo comparativo entre o uso do protetor descartável de fone de ouvido e o uso do policloreto de vinila (PVC)

Recursos de bioseguridad en la evaluación audiológica básica: estudio comparativo entre el uso del protector desechable de audiófonos y el uso del policloreto de vinila (PVC)

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Abstract

Objective: The study compared the effects of the Disposable Earphone Protector® and the PVC film (Polyvinyl Chloride) on pure-tone and speech auditory thresholds, and the effect of latter material on acoustic reflex thresholds, to verify the possibility of adopting these materials as biosafety action. **Method:** Participants were 72 normal-hearing subjects with ages between 18 and 40 years, evaluated

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MRS – manuscript writing and review, elaboration of the abstract in English and Spanish, and supervision of the manuscript elaboration in all stages.
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at a speech-language outpatient clinic of a Federal university. **Results:** No statistically significant difference was found between the materials regarding the acoustic reflex thresholds. On the other hand, the audiometry and SRT (Speech Recognition Threshold) thresholds showed a small difference, however, within the 95% confidence interval. **Conclusion:** According to the results and the American Speech-Language-Hearing Association – ASHA recommendation it can be concluded that neither the Disposable Earphone Protector® or the PVC film interfere in the audiological evaluation.

Keywords: Audiology; Exposure to Biological Agents; Audiometry.

Resumo

Objetivo: O estudo comparou o efeito do Protetor Descartável de Fone de Ouvido® e do filme PVC (Policloreto de Vinila) nos limiares de audibilidade para tons puros, fala e o efeito deste último material nos limiares do reflexo acústico, afim de verificar a possibilidade de adoção destes materiais como medidas de biossegurança. **Método:** Realizado com 72 indivíduos de 18 a 40 anos, com audição normal, em uma clínica escola de fonoaudiologia de uma universidade federal. **Resultados:** Nos limiares do reflexo acústico, não houve diferença estatisticamente significante entre os materiais utilizados. Já na audiometria e no LRF (Limiar de Reconhecimento de Fala) houve uma pequena diferença nos limiares, porém manteve-se dentro do intervalo de segurança de 95%. **Conclusão:** Diante dos resultados e recomendação da *American Speech-Language-Hearing Association* – ASHA pode-se afirmar que o Protetor Descartável de Fone de Ouvido® e o filme PVC não interferem na avaliação audiológica.

Palavras-chave: Audiologia; Exposição a Agentes Biológicos; Audiometria.

Resumen

Objetivo: El estudio comparó el efecto del Protector Desechable de Audiófonos® y del film PVC (Policloreto de Vinila) en los liminares de audibilidad para tonos puros, habla, y el efecto de este ultimo material en los liminares del reflejo acústico, a fin de averiguar la posibilidad de adoptar estos materiales como medidas de bioseguridad. **Método**: Realizado con 72 individuos de 18 a 40 años con audición normal, en una clínica escuela de Fonoaudiologia de una universidad federal. **Resultados**: En los liminares del reflejo acústico, no hubo diferencia estadísticamente significante entre los materiales utilizados. Pero en la audiometría y en el LRH (Liminar de Reconocimiento del Habla) hubo una pequeña diferencia en los liminares, que, todavía, se ha mantenido dentro del intervalo de seguridad de 95%. **Conclusión**: Frente a los resultados y recomendaciones de la *American Speech-Language-Hearing Association*-ASHA se puede firmar que el Protector Descartable de Audiófonos® y el film PVC no interfieren en la evaluación audiológica.

Palabras claves: Audiología; Exposición a Agentes Biológicos; Audiometría.

Introduction

In Audiology clinical practice, the constant use of audiological equipments may favor microorganism growth in the earphones and, thus, the transmission of infectious diseases from one individual to another[1,2].

Prevention is the best way to minimize the risks of contamination by pathogenic agents through contact with blood or body fluids. Thus, all health professionals should adopt prevention actions to every procedure involving patients, regardless of the diagnosis, the presented situations, and the service specialty[3].

The disinfection of supra-aural headphones is usually done with isopropyl alcohol 70% for 5 minutes. The use of alcohol at this concentration is a reasonable choice for an intermediate level disinfection of instruments such as the otoscope, and the rubber and stem of the supra-aural headphones[4].

A wide range of patients seek for audiological services, differing in factors such as age, primary disease, nutritional condition, exposure to pharmacological interventions, and socioeconomic level. Hence, audiologists evaluate people with impaired immune systems, such as patients with different levels of infection by the Human Immunodeficiency Virus (HIV)[5,6,7]. Although the risk of HIV transmission in audiological assessment is remote, individuals must not be exposed to any contamination risks[8]. In Brazil, about 25.5% of HIV patients are co-infected with tuberculosis (TB)[9]. Although vaccination against tuberculosis (BCG) is mandatory, it does not present a good protective action. Thus, the HIV-TB association currently represents a serious public health problem[10].

More recent estimates indicate a sensitive raise of hepatitis B and C cases around the world, which means that more than 185 million people are infected with some type of hepatitis[11]. Some studies have stated that the hepatitis B virus can cause contamination by direct contact with body fluids, which are a potential source of transmission. However, deeper investigations are necessary on matters regarding horizontal, nosocomial and occupational transmission[8]. Given this situation, vaccination against the B virus (HVB) is recommended to groups of professionals considered vulnerable[12]. There is no vaccine against hepatitis C, and the only preventive action against it is the adoption of basic precautions; when there is greater risk, the use of double gloves is recommended[8].

Cerumen is a body substance that has the role of antimicrobial protection through the skin of the external auditory canal (EAC), establishing a low ph. It is not considered an infectious agent until it is contaminated with blood or mucus[13]. Thus, contact instruments such as speculums, rubber olives, ear-molding materials and intra-canal hearing aids should be cleaned and sterilized previously and after their use, especially if there is visible blood inside or next to the cerumen containing microbes[1,2,14].

In this context, it is possible to notice that audiology professionals do not know for sure what are the potential risks of cross-infection by the viruses found on the equipment commonly used in audiological assessments. This lack of knowledge surely creates an environment with greater transmission risk for infectious diseases[15].

Generally, in audiology practice, direct or indirect contact transmission represents the most frequent form of transmitting diseases[2]. In the attempt to prevent this form of contamination, it is necessary to adopt some biosafety measures.

The most commonly used materials for bacteria, virus and fungus disinfection are alcohol 70%, glutaraldehyde 2%, hydrogen peroxide 7.5%, peracetic acid 0.2%, and sodium hypochlorite 1%[16,17]. However, it is known that the earphones used in pure-tone audiometry and acoustic immittance measures are covered with rubber, and the excessive and frequent use of these materials will cause dryness of the earphone rubber, damaging it[18]. Therefore, the use of these materials is not feasible for disinfection in clinical audiology practice. Substituting the earphone rubber for each new patient might be an alternative biosafety action to be adopted. However, this procedure would compromise the calibration of the equipment.

A safe and efficient action against patient-professional and professional-patient contamination is using personal protective equipment (PPE), which create a protective barrier. Its use must be obligatory to prevent from contact with blood and organic fluids[19].

The lab coat should be light-colored (for better visualization of the dirt), have high neckline and long sleeves. This PPE must be worn exclusively in the workplace, and changed periodically. The use of gloves is another important precaution, especially to reduce the risk of microorganism cross-infection between professionals and patients[20].

In addition to the use of these equipment as biosafety actions in audiology services, a specific caution is still necessary regarding the use of supra-aural earphones. The polyvinyl chloride (PVC) and the Disposable Earphone Protector®[21] have been considered among the PPE investigated for their viability in clinical audiology practice. Both materials are disposable, waterproof and should be replaced after each use[16]. The PVC film provides a protective pellicle, preventing direct contact of the skin on the rubber. However, there is no clear and consensual data in literature regarding the effect of this pellicle on the sound pressure projected by the earphone. To solve the contamination problem with the use of supra-aural earphones, a specific biosafety action for infection control during the procedures is necessary.

Considering the above, this study had the aim to compare the effects of the Disposable Earphone Protector®[21] and the PVC film (polyvinyl chloride) on pure-tone and speech auditory thresholds, and the effect of this latter material on acoustic reflex thresholds, to verify the possibility of adopting these materials as biosafety actions.

Methods

The sample comprised 72 normal-hearing individuals (36 female and 36 male) with ages between 18 and 40 years. Individuals who presented any acoustic reflex alterations or any degree of hearing loss were excluded. The subjects signed the Free and Informed Consent approved by the Research Ethics Committee of the University Hospital where the study was conducted, under protocol number 523/11.

The study investigated the effects of using PVC and Disposable Earphone Protector® to ensure the health of patients undergoing audiological evaluation against possible risks of opportunistic infections. It was carried out at the outpatient clinic of a Federal university, from February to December 2012. The following equipment was used: Press Control® otoscope and speculum;Interacoustics® audiometers, models AC 40 and AC 33; and Interacoustics® middle ear analyzer, model AT 235h.

The procedures conducted were: anamnesis, meatoscopy, pure-tone audiometry, speech audiometry (speech recognition threshold – SRT), and acoustic immittance measures.

The sequence of audiological tests was carried out under three different conditions: in situation 1, the subject was submitted to the tests without using any protective barrier on the TDH-39 phone; in situation 2, the subject was submitted to the same tests, however, with the earphones protected by PVC film; and, finally, in situation 3, the subject was submitted to the tests using the Disposable Earphone Protector®[21]. Data from each subject was collected in one single session. The order of the procedures was controlled by sex and ear, alternating the first ear tested for both the male and female groups, to avoid interpretation biases, such as: learning factor during the conduction of the tests, tiredness, inattention, and disinterest. From this perspective, the tests were performed using 12 different combinations of the three situations described.

The collection of data on acoustic immittance measures, which focused on the measures of acoustic reflex thresholds, was performed as it follows: without protective barrier and with PVC, starting from the right ear (RE); and without protective barrier and with PVC, starting from the left ear (LE), for both male and female subjects.

Results were evaluated and received specific statistical treatment, using the repeated measures ANOVA method and the T-Student test for paired samples in the software IBM SPSS 19.0 ($p \leq 0.05$). Data were then interpreted qualitatively and related to the literature findings

Results

The evaluation of the auditory thresholds and the SRT was performed under three different conditions: without protective barrier, with PVC, and with the Disposable Earphone Protector®[21]. The acoustic reflex was tested under two conditions: without protective barrier, and with PVC. The analysis was conducted by ear, sex, and type of protective material. The statistical tests used to analyze the results were the T-Student for paired samples and the repeated measures ANOVA test for the three correlations investigated.

Table 1 describes the means, standard deviations, medians, and minimum and maximum values for the audibility thresholds obtained for each tested frequency on the right and left ears, under thethree protective conditions using supra-aural earphones.

Table 2 describes the significance level (*p* value) for the audibility thresholds by frequency on the right and left ears, for the comparisons between the conditions using supra-aural earphones without protective barrier, with PVC, and with the Disposable Earphone Protector®[21].

Table 3 shows the confidence intervals of the audibility thresholds obtained by frequency on the right and left ears for the use of supra-aural earphones under the conditions without protective barrier, with PVC and with disposable earphone protector®.

Table 4 shows the analyses of mean, standard deviation, minimum and maximum values for the SRT on both ears under the three investigated conditions.

Table 1. Descriptive analysis of the audibility thresholds by frequency on the right and left ears, in the conditions without protective barrier, with PVC, and with Disposable Earphone Protector®on supra-aural earphones.

Hz	Auditory thresholds (dB)											
	Mean ± sd			Median			Minimum			Maximum		
	Without barrier	With PVC	With protector	Without barrier	With PVC	With protector	Without barrier	With PVC	With protector	Without barrier	With PVC	With protector
250	7.47 ± 5.883	8.54 ± 6.338	7.95 ± 6.042	10	10	7,50	-10	-5	-5	20	25	30
500	8.33 ± 5.189	10.03 ± 5.272	8.58 ± 5.568	10	10	10	-5	-5	-5	20	25	25
1000	6.25 ± 6.016	7.08 ± 5.500	6.94 ± 5.767	5	5	5	-10	-5	-5	25	25	25
2000	5.17 ± 6.407	5.14 ± 6.662	5.10 ± 5.956	5	5	5	-10	-10	-5	25	25	25
3000	5.42 ± 6.045	5.94 ± 5.793	5.90 ± 5.753	5	5	5	-10	-10	-10	25	20	20
4000	5.31 ± 7.175	6.22 ± 6.618	5.90 ± 7.038	5	5	5	-10	-10	-10	25	25	25
6000	10.17± 7.964	12.43 ± 7.977	11.84 ± 7.704	10	10	10	-10	-10	-5	35	40	35
8000	5.07 ± 8.278	6.98 ± 8.346	5.31 ± 8.367	5	5	5	-10	-10	-10	25	30	30

sd: standard deviation; Hz: Hertz; dB: decibel.

Table 2. Significance levels for comparisons of audibility thresholds by frequency on the right and left ears, between the testing conditions using supra-aural earphones without protective barrier, with PVC, and with disposable earphone protector®.

Frequencies	p	
	RE	LE
250 Hz	0.135	0.382
500 Hz	0.003	0.003
1000 Hz	0.266	0.383
2000 Hz	1.000	0.918
3000 Hz	0.673	0.190
4000 Hz	0.051	0.851
6000 Hz	0.177	0.000
8000 Hz	0.016	0.074

*p:*Significance Level; RE: right ear; LE: left ear.

Table 3. Confidence intervals of the audibility thresholds obtained by frequency on the right and left earsfor the use of supra-aural earphones under the conditions without protective barrier, with PVC and with disposable earphone protector®.

Hz	Auditory thresholds (dB)					
	CI RE			CI LE		
	Without barrier	With PVC	With protector	Without barrier	With PVC	With protector
250	6.18 - 8.82	7.30 - 10.20	6.97 - 9.84	5.98 - 8.88	6.79 - 9.87	6.09 - 8.91
500	7.42 - 10.08	9.08 - 11.48	7.36 - 10.00	6.82 - 9.01	8.51 - 11.08	7.17 - 9.77
1000	5.03 - 7.74	5.94 - 8.37	5.85 - 8.46	4.98 - 7.80	5.64 - 8.39	5.33 - 8.15
2000	3.37 - 6.49	3.47 - 6.67	3.61 - 6.39	3.96 - 6.88	3.66 - 6.75	3.79 - 6.62
3000	4.37 - 7.02	4.34 - 7.05	4.92 - 7.30	3.62 - 6.65	4.81 - 7.55	4.19 - 7.20
4000	2.91 - 6.25	4.67 - 7.55	4.23 - 7.44	4.35 - 7.74	4.65 - 7.99	4.26 - 7.69
6000	8.07 - 11.80	9.33 - 12.89	9.68 - 12.96	8.53 - 12.31	11.82 - 15.68	10.39 - 14.33
8000	3.03 - 6.55	4.75 - 8.58	3.29 - 6.85	3.22 - 7.47	5.27 - 9.31	3.41 - 7.70

Hz: Hertz; dB: decibel; CI: confidence interval; RE: right ear; LE: left ear.

Table 4. Descriptive analysis of the speech recognition threshold on the right and left ears, in the conditions without protective barrier, with PVC, and with Disposable Earphone Protector® on supra-aural earphones.

Speech recognition thresholds (dB)			
		RE	**LE**
Mean ± sd	Without barrier	10 ± 6.500	10.76 ± 6.261
	With PVC	12.36 ± 5.437	12.64 ± 6.222
	With protector	11.11 ± 4.980	11.67 ± 4.965
Median	Without barrier	10	10
	With PVC	15	15
	With protector	10	10
Minimum	Without barrier	-10	-5
	With PVC	-5	-5
	With protector	0	0
Maximum	Without barrier	25	25
	With PVC	25	25
	With protector	25	25

sd: standard deviation; RE: right ear; LE: left ear; dB: decibel.

Table 5 represents the *p* values obtained in the comparison of SRT values between the conditions without barrier, with PVC and with Disposable Earphone Protector®[21].

Table 6 shows the confidence intervals of right and left ears on the Speech Recognition Threshold test under the three investigated conditions.

Table 5. Significance levels for comparisons of speech recognition thresholds on the right and left ears, between the testing conditions using supra-aural earphones without protective barrier, with PVC, and with disposable earphone protector®.

SRT	P	
	RE	**LE**
	0.001	0.019

*p:*Significance Level; RE: right ear; LE: left ear.

Table 6. Confidence intervals for comparisons of speech recognition thresholds on the right and left ears, between the testing conditions using supra-aural earphones without protective barrier, with PVC, and with disposable earphone protector®.

Speech recognition thresholds (dB)					
CI RE			**CI LE**		
Without barrier	**With PVC**	**With protector**	**Without barrier**	**With PVC**	**With protector**
8.47 - 11.53	11.08 - 13.64	9.94 - 12.28	9.29 - 12.24	11.18 - 14.10	10.50 - 12.83

dB: decibel; CI: confidence interval; RE: right ear; LE: left ear.

Table 7 displays the mean, standard deviation, minimum and maximum values of acoustic reflex thresholds obtained for the frequencies 500, 1000, 2000 and 4000 Hz with and without PVC, in both ears.

Table 8 shows the *p* values for the comparisons between the conditions with and without PVC on the acoustic reflex thresholds.

Table 7. Descriptive analysis of the acoustic reflex thresholds obtained for the right and left ears, in the conditions without protective barrier and with PVC.

Hz	Acoustic reflex thresholds (dB)							
	Mean ± sd		Median		Minimum		Maximum	
	Without barrier	With PVC	Without barrier	With PVC	Without barrier	With PVC	Without barrier	With PVC
500	88.26 ± 9.052	88.68 ± 8.548	90	90	65	70	110	105
1000	88.72 ± 9.382	89.31 ± 8.921	90	90	65	65	105	110
2000	87.67 ± 9.697	89.13 ± 10.265	90	90	65	65	115	120
4000	91.67 ± 13.049	91.70 ± 12.671	90	90	65	55	120	125

sd: standard deviation; Hz: Hertz; dB: decibel.

Table 8. Significance levels for comparisons of acoustic reflex thresholds on the right and left ears, between the testing conditions using supra-aural earphones without protective barrier and with PVC.

Frequencies	P	
	RE	LE
500 Hz	0.954	0.326
1000 Hz	0.383	0.893
2000 Hz	0.354	0.085
4000 Hz	0.649	0.624

*p:*Significance Level; RE: right ear; LE: left ear.

Discussion

The American National Standards Institute (ANSI)[22], the International Standards Organization (ISO) and the American Speech-Language-Hearing Association (ASHA)[23] publish updated guidelines on how to conduct procedures and what should be the precautions in the pure-tone audiometry[24].

The audiological procedures are frequently described in literature. However, little information is retrieved on the manners of ensuring the health of patients, speech-language pathologists and audiologists, and on the control of infection itself. ASHA[23] recommends that instruments that have physical contact with patients should be cleaned and disinfected after each use. Nevertheless, it is known that the disinfection of the supra-aural earphones using alcohol 70% damages the equipment's rubber[18] and, as the material is repeatedly used, it may cause the rubber to get dried, which leads to acoustic alterations of the earphone. The use of peracetic acid 0.2%, glutaraldehyde 2% or sodium hypochlorite 0.5% would require the equipment to be immersed for 30 minutes, 10 minutes and 30 minutes, respectively[25]. In addition, only the peracetic acid 0.2% has sterilizing power, since glutaraldehyde 2% and hypochlorite present only disinfectant action on the materials. Although the hydrogen peroxide 7.5% (Sporox) present action on bacteria, viruses, fungi, microbacteria and spores[25], 6 hours of immersion[1,2] are required and special drying with air compressor.

Although most audiologists report not knowing the potential risks of cross-infection, they report washing hands as a simple action to reduce the risks of contracting infectious diseases[1,26]. In addition, an alternative that has been found is the use of protective barriers on the supra-aural earphone during the audiological assessment, according to the recommendation described on the Manual for audiometry, sub-item guidelines for infection control[22,23].

In Brazil, few studies have been retrieved on the subject. However, in one of them, the authors[18] investigated the interference of the PVC film on supra-aural earphones by comparing the results of pure-tone audiometry with and without the use of this protective barrier. They noticed a small increase of pure-tone thresholds in all frequencies with the use of the PVC pellicle; however, statistically significant difference was found only at 6000 Hz. The authors concluded the study emphasizing the importance and need for further studies deepening the subject to better evaluate the effectiveness of the PVC film.

The descriptive analysis of audibility thresholds presented by the subjects on both ears showed differences in all the investigated situations (Table 1). However, the mean difference did not exceed 4 dB in all the frequencies tested. Knowing that in audiometry the thresholds are tested in intervals of 5 dB, the difference observed –inferior to 4 dB – does not imply actual variation in the audiometric examination. Statistical tests (Table 3) did not show statistical significance, corroborating the conclusion that the difference found does not change clinical practice. An important fact to be considered is that variations in auditory thresholds are also observed in studies without protective barrier in test-retest conditions. Thus, it might be stated that the threshold variations observed did not depend directly on the use of the investigated materials[3,23]. In this sense, the barriers investigated in this study can be used, and corroborate the recommendations of similar studies regarding the use of disposable earphone protectors in audiometry[22,23].

Nevertheless, statistically significant differences were found at 500 Hz in both ears, 6000 Hz in the left ear, and 8000 Hz in the right ear (Table2). Such results might be justified by studies that report that variability of thresholds may occur at lower frequencies due to air leaks between the earphone pad and the headset[27]. Moreover, threshold variations at higher frequencies may happen due to the variability of the position of supra-aural earphones, and to the very anatomy of the external ear and the cartilaginous part of the external auditory canal (EAC).

Other studies have analyzed high frequency audiometry[28]and the interference of using PVC film in the audiometry[18]. They also found increased mean of the thresholds at 6000 Hz. One of the reasons presented in both studies regards the presence of stationary waves when continuous stimulus is used or when there is a distance between the earphone output and the tympanic membrane. This phenomenon usually occurs at frequencies higher than 3000 Hz. Acoustic physics states that the creation of stationary waves is favored when the wave length of the tone is close to the length of the EAC, thus varying the sound pressure level along the EAC. The pattern of these waves depends on the dimension of the external ear, the impedance of the middle ear, and the characteristics of the sound source. Sound waves with the same frequency and the same wavelength move towards the same direction, but from opposite sides, causing the superposition principle. Thus, the initial signal-test is altered and it becomes more difficult to measure the actual sound pressure level around the tympanum. According to the literature reports[18], when these stationary waves occur between the earphone and the ear of the individual, changing the earphone position can remove the effect. However, if the stationary waves occur between the PVC film and the supra-aural earphone and/or between the disposable earphone protector and the supra-aural earphone, repositioning the earphones would not solve this acoustic physics phenomenon. There is still the possibility that the PVC tension may cause a loss of acoustic energy. Nevertheless, the hypotheses presented could not be confirmed or answered in this study.

Studies on the variability of the Speech Recognition Thresholds (SRT) in the test-retest of normal hearing adults in the conditions of silence and competitive noise found variability of thresholds under 3 dB in 70% of the ears in silence, and 88% in noise[29]. Although we did not have the aim to investigate SRT in noise, this study also identified a difference lower than 3 dB when comparing the means (Table 4),in all three investigated conditions (without barrier, with PVC film, and with disposable earphone protector), with statistically significant differences in both ears (Table 5). By analyzing tables 4 and 6, it was possible to verify that the difference in the auditory thresholds of both ears under the three investigated conditions was close and within the confidence interval established by the confidence analysis, hence, there is no need to suggest significant and actual changes in clinical practice.

The contralateral acoustic reflex occurs between 70 and 100 dB above the auditory threshold[30]. In this study, the mean for all frequencies was within this interval (Table 7) and, therefore, no significant differences were observed in both ears, under the investigated conditions (Table 8), confirming the non-interference of the PVC material in obtaining this reflex. This may be due to the fact that this is an objective test that does not depend on the patient's response, takes less time to be performed than audiometry, and has a wide variation of the normality standards for the acoustic reflex, from 70 to 100 dB SPL above the pure-tone threshold[28]. However, it is not possible to affirm which of these hypotheses actually happened in this study. Thus, further studies are necessary to research the materials we investigated, both in the audiological evaluation and in obtaining the acoustic reflex thresholds.

Considering that the basic audiological assessment consists on audiometry and measuring the acoustic reflex thresholds, that audiological diagnosis is not carried out with only one isolated test, that the differences between the mean pure-tone thresholds were not above or below the confidence intervals in all three investigated conditions, and also that there is a recommendation from ASHA[23] regarding the use of protective barriers in supra-aural earphones for infectious diseases control, it is possible to suggest that the materials investigated in this study do not interfere in the results of both tests. Therefore, either one of the materials may be used in clinical audiology practice. However, as a precaution, further studies should be conducted with individuals with hearing loss, so that these earphone protectors can be recommended in the future.

Conclusion

Differences were found between the testing conditions in the mean pure-tone and speech recognition thresholds of almost all frequencies tested: without protective barrier, with PVC film, and with Disposable Earphone Protector®[21]. However, the variability found was within the confidence interval in all the investigated conditions. Moreover, the significant differences found do not depend directly on the use of the investigated materials, since they were also observed in studies without protective barrier in test-retest situations. Regarding the acoustic reflex measures, no statistically significant differences were found in the investigated conditions.

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