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Revision articles

The hearing of smokers: a review

Audição em fumantes: uma revisão

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ABSTRACT

Amidst the factors that may cause hearing impairment, one can name smoking, since studies have shown that use of tobacco might have an ototoxic effect. The aim of this revision was to analyse scientific productions regarding smoking effects on the auditory system. Methodology was composed by database research, in which national and international scientific articles, in English or Portuguese, published from 2009 to 2016, were included. After being selected and examined, the articles were classified according to their type, and characterised into five categories: database, article title, author, year and country of publication. Afterwards, the criteria used by each author in their production were evaluated, considering population sample, age span and gender. Finally, analysis of auditory tests used in smokers and exclusion criteria of each study was performed. Thus, through the published studies, it was concluded that the use of tobacco influences the onset of hearing loss, damaging mostly high frequencies hearing thresholds and neural transmission of audio information.

Keywords: Tobacco; Hearing; Smoking

RESUMO

Dentre os fatores que influenciam o aparecimento de alterações auditivas pode-se citar o tabagismo, já que estudos revelam que o uso do tabaco pode causar um efeito ototóxico na audição. O objetivo do presente estudo foi analisar as produções científicas sobre o efeito do cigarro no sistema auditivo. A metodologia constou de levantamento dos periódicos indexados nas bases de dados, e foram incluídos na revisão de literatura os artigos científicos nacionais e internacionais, publicados em língua portuguesa ou inglesa, entre os anos de 2009 a 2016. Posteriormente a seleção e análise dos artigos na íntegra, foram classificados de acordo com a sua natureza, caracterizando-os em cinco categorias: base de dados, título do artigo científico, autor, ano e país da publicação. Em seguida, foram analisados os critérios utilizados pelos autores dos respectivos artigos, levando em consideração a amostra populacional, a faixa etária e o sexo. Por fim, foram feitas as análises dos exames auditivos utilizados em fumantes e os critérios de exclusão de cada estudo. Assim, por meio dos estudos publicados conclui-se que o uso do tabaco influencia no aparecimento de perda auditiva, prejudicando principalmente os limiares auditivos das altas frequências e inclusive a transmissão neural da informação auditiva.

Descritores: Tabaco; Audição; Hábito de Fumar

INTRODUCTION

The life expectancy of a smoker is 25 percent lower than a non-smoker. The most harmful substances present in tobacco and absorbed by the body are: thiocyanate (present in saliva), carboxyhemoglobin (found in blood), and carbon monoxide (in exhaled air). When inhaling cigarette smoke, approximately 2,500 harmful substances enter the body [1].

Hearing is one of the most important functions of the human communication system, especially in the oral language aspect, since the development of oral language is dependent upon the hearing system working perfectly. Otherwise, the individual may develop difficulties with communication, like delayed speech development, learning disabilities, and social and emotional disorders [2].

There are several factors that cause hearing loss, such as noise exposure, meningitis, encephalitis, head trauma, otosclerosis, ototoxicity, diabetes, and others [3].

Authors[4] show use of the cigarette can affect hearing due to the creation of oxygenation deficiency in blood vascular obstructions and changes in blood viscosity. However, there is still controversy about the effect of smoking on the auditory system because few studies exist concerning the subject.

Several studies have linked tobacco use with the presence of hearing loss, [4-6] however, these studies suggest the need to expand research on this subject. More details are needed about the types of changes that tobacco can cause and locale of lesions.

Ototoxicity is caused by carbon monoxide (CO) present in components of the cigarette. This reduces oxygen levels in the cochlea, resulting in vasoconstriction, increased blood flow, reduced oxygen transport, and difficulty in oxyhemoglobin dissociation [7]. All these changes can affect the blood supply to the cochlea, causing damage to the hair cells of the organ of Corti, and creating hearing problems [8].

The objective of this study was to analyze the scientific resources available in the literature published in the period from 2009 to 2016 in English, Portuguese, and Spanish, that concerned the effect of cigarette smoking in the auditory system.

METHODS

This is a literature integrative article review with the purpose to gather and synthesize research results, in a systematic and orderly manner; to contribute to the deepening of knowledge of the subject investigated [9].

For the preparation of this integrative review, the following steps were conducted [10]: definition of the investigated problem in the review and research objectives; selection of the sample establishing the inclusion and exclusion criteria of the publications; strategies for searching the literature; critical analysis of studies; data collection; presentation; and discussion of results.

The problem defined for the research was: What was produced in the literature about the hearing of smokers?

The pursuit of scientific publications was in national and international journals indexed in databases recognized internationally in the area of health sciences. Specifically, search was conducted using: Latin American and Caribbean Health Sciences Literature (LILACS), Science Electronic Online (SciELO), Medical Literature Analysis and Retrieval System Online (MEDLINE), and the Virtual Health Library (VHS). The following keywords were used: audição*, fumantes* / *hearing; smoking" "emissões otoacústicas, fumantes* / *otoacoustics emissions; smoking", "perda auditiva, fumantes* / *hearing loss, smoking", "fumantes; PEATE* / *smoking, ABR" "fumantes; audiometria* / *smoking; audiometry" and "fumantes, processamento auditivo* / *smoking; Auditoryprocessing ".*

Initially, access to publications was performed by reading and analyzing summaries through the Brazilian-based Regional Library of Medicine (BIREME) virtual library (www.bireme.br) to determine the literature that could meet the interests for this study.

In this process, criteria for inclusion were established. Such criteria were based on the following: national and international scientific articles published in the last seven years (2009 to 2016) in the languages of Portuguese, English, or Spanish. The studies needed to address tobacco as the subject and with a relation to the effects on the auditory peripheral and / or central auditory system.

During the search, a total of 484 articles, were found using the keywords and their combinations. No results were found when using the keywords *"smokers; auditory processing."*

All articles where tobacco was presented with associated factors (noise, drugs, and chemical substances) were excluded,_as were articles that reported the presence of middle ear alteration (18 studies), articles with unavailable texts (60 studies), in languages outside of the inclusion criteria (6 articles), and others concerning health problems due to cigarette use (304 studies). This resulted in a total

of 474 discarded articles. The exclusion criteria took into consideration the articles, that after identification through titles and abstracts, did not fit the central objective of the research.

For analysis, only 10 articles were selected. Of the 10 selected articles, three were found exclusively in the LILACS database; five in MEDLINE; and two found both in the LILACS and MEDLINE databases. Regarding the language of the articles selected, five were in English and five were in Brazilian Portuguese.

After the selection and analysis of the full articles, the articles were then classified according to their type (national / international publication), and were characterized into five categories: database, title of scientific article, author, year, and country of publication.

Next, the criteria used by the authors of the respective articles were analyzed, with consideration of the following variables: population sample, age group, and gender.

Finally, for each individual study, the analysis of hearing tests for smokers and the exclusion criteria were performed.

Table 1 shows the studies classified according to their type (national / international) in the database, the scientific article title, author, year, and country of publication.

Table 2 presents the criteria used by the authors in the surveys, taking into account the following variables: population sample, age group, and gender.

Table 1. Articles on the relationship between the practice of smoking and the auditory system, classified according to their type (national / international publication): database, authors, year, and country of publication

T	Data base	Name of articles	Author	Year - Country
Nationals				
1	LILACS	Low and high frequency tonal threshold audiometry: comparison of auditory thresholds between smokers and non-smokers	Oliveira e Lima	2009 - Brazil
2	LILACS	Cigarette smoking as a risk factor for hearing loss	Paschoal and Azevedo	2009 - Brazil
3	LILACS	Prevalence of hearing loss and associated factors in the elderly population of Londrina, Paraná: preliminary study	Meneses et al.	2010 - Brazil
4	LILACS	Comparative study of acoustic immittance measures in smokers and non-smokers	Mourão e Baeck	2014 - Brazil
5	LILACS	Auditory brainstem evoked potentials in smokers	Martins et al.	2016 - Brazil
International				
6	MEDLINE	The Effect of Smoking on the Hearing Status - A Hospital-Based Study	Kumar et al.	2013 -India
7	MEDLINE	Cigarette smoking effect on human cochlea responses	Rogha et al.	2015
8	MEDLINE	Cigarette Smoking Causes Hearing Impairment among Bangladeshi Population	Sumit et al.	2015 - United States
9	MEDLINE	Otoacoustic Emissions in Smoking and Nonsmoking Young Adults	Jedrzejczak et al	2015
10	MEDLINE	Effect of Cigarette Smoking and Passive Smoking on Hearing Impairment: Data from a Population-Based Study	Chang et al.	2016 – South Korea

Legend: T = total articles

Table 2. Criteria used by the authors of the articles analyzed considering the variables: population sample, age group and gender

T	Data base	Article Name	Sample Population	Age	Gender
1	LILACS	From threshold tonal audiometry at low and high frequency: comparison of auditory thresholds between smokers and non-smokers	GNT (non-smokers group): 30 and GT (smoking group): 30	18 to 40 years of age	Male
2	LILACS	Cigarette smoking as a risk factor for hearing loss	NF (non-smokers): 72 and F (smokers: 72).	20 to 31 years of age	Male and female
3	LILACS	Prevalence of hearing loss and associated factors in the elderly population of Londrina, Paraná: preliminary study	Variables: Smoking, alcohol, age, diabetes, and hypertension. Smoking variable: assessment of smokers, former smokers and passive smokers (n = 31)	60 to 90 years of age	Male and female
4	LILACS	Comparative study of acoustic immittance measures in smokers and non-smokers	GT (smoking group): 40 and GNT (non-smoking group): 40	Average age of 40 to 45	Male and female
5	LILACS	Auditory brainstem evoked potentials in smokers	G1 (non-smoker): 20 G2 (smokers): 20	20 to 59 years of age	Not included
6	MEDLINE	The Effect of Smoking on the Hearing Status - A Hospital-Based Study	Smokers (n = 108) and nonsmokers (n = 40)	20 to 60 years of age	Male
7	MEDLINE	Cigarette smoking effect on human cochlea responses	32 subjects, divided into two groups, one with a history of cigarette smoking and one with non-smokers.	20 to 50 years of age	Male
8	MEDLINE	Cigarette Smoking Causes Hearing Impairment among Bangladeshi Population	Control group: 94 non-smokers and Study group: 90 smokers	18 to 60 years of age	Male
9	MEDLINE	Otoacoustic Emissions in Smoking and Nonsmoking Young Adults	Smokers (12 men and 12 women) and Non-smokers (12 men and 12 women)	20 to 27 years of age	Male and female
10	MEDLINE	Effect of Cigarette Smoking and Passive Smoking on Hearing Impairment: Data from a Population-Based Study	12,935 participants: 3,374 smokers, 2,772 passive smokers and 6,769 non-smokers	> 19 years of age	Male and Female

Legend: T = total of articles; G = group; N = numbers

According to the present review, several tests were conducted to evaluate the auditory system of the sample subjects. Table 3 presents the analyzes of the auditory tests used to investigate the functioning of the peripheral and / or central auditory system in smokers: conventional audiometry (10; 100%), high frequency audiometry (4; 40%), logoaudiometry (2; 20%), suppressive effect of otoacoustic emissions (2; 20%), spontaneous otoacoustic emissions (1; 10%), transient evoked otoacoustic emissions (1; 10%), brainstem auditory evoked potentials (1; 10%). In addition, Table 3 also shows the exclusion criteria for each study. The studies that reported exclusion criteria eliminated all individuals who presented any symptoms or complaints of changes that could influence the audiological findings of the tests. This removed doubts about the effect of tobacco on the auditory system.

Table 4 shows all the results of the exams in smokers presented by each study.

Table 3. Auditory examinations and exclusion criteria used by the authors of the articles studied

T	Data base	Article Name	Hearing exams	Exclusion Criteria
1	LILACS	From threshold tonal audiometry at low and high frequency: comparison of auditory thresholds between smokers and non-smokers	Conventional Audiometry and High Frequency Audiometry	Otologic disease, tinnitus and / or dizziness, report of hearing loss, previous otologic surgery, changes in otoscopy, noise exposure, auditory threshold greater than 25 dB NA, systemic arterial hypertension, diabetes mellitus and / or neurological disease, illiterate individuals or people with visual impairment.
2	LILACS	Cigarette smoking as a risk factor for hearing loss	Conventional audiometry, high frequency audiometry, immittanciometry, EOATE and suppression effect	Ex-smokers, individuals with alteration of the middle ear, individuals with complaints of metabolic alteration, hormonal alteration, noise-induced hearing loss and hearing loss induced by ototoxic and / or chemotherapeutic drugs
3	LILACS	Prevalence of hearing loss and associated factors in the elderly population of Londrina, Paraná: preliminary study	Conventional Audiometry	Not included
4	LILACS	Comparative study of acoustic immittance measures in smokers and non-smokers	Conventional audiometry, logoaudiometry and immittanciometry	Auditory compromises of other natures.
5	LILACS	Auditory brainstem evoked potentials in smokers	Conventional audiometry, immittanciometry and BAEP	Individuals with audiometric thresholds worse than 25 dBNA, individuals who presented type B or C curve and absence of contralateral acoustic reflex in two or more frequencies.
6	MEDLINE	The Effect of Smoking on the Hearing Status-A Hospital-Based Study	Audiometry in the frequencies of 500 to 6000 Hz	History of ototoxic drug use, diabetes mellitus, hypertension, any type of loss, severe and frequent ear infections, ear surgery, head trauma, family deafness, exposure to noise.
7	MEDLINE	Cigarette smoking effect on human cochlea responses	Conventional and high frequency audiometry, immittanciometry, EOATE and EOADP.	Conductive or unilateral hearing loss.
8	MEDLINE	Cigarette Smoking Causes Hearing Impairment among Bangladeshi Population	Audiometry in the frequencies 1, 4, 8 and 12 kHz	Individuals who had a habit of drinking alcohol and wearing headphones, a previous history of ear diseases and who were ill at the time of the research.
9	MEDLINE	Otoacoustic Emissions in Smoking and Nonsmoking Young Adults	EOAE, EOATE and EOADP immittanciometry and conventional audiometry	Hearing disorders that could affect the results
10	MEDLINE	Effect of Cigarette Smoking and Passive Smoking on Hearing Impairment: Data from a Population-Based Study	Conventional Audiometry	Not included

Caption: EOAT and EOATE = otoacoustic emissions evoked by transient stimulus; PEEP = brainstem auditory evoked potential; EOADP = otoacoustic emissions evoked by distortion product; EOAE = spontaneous otoacoustic emissions

Table 4. Results of hearing exams presented in studied articles

T	Data base	Article Name	Results of hearing exams
1	LILACS	From threshold tonal audiometry at low and high frequency: comparison of auditory thresholds between smokers and non-smokers	Auditory thresholds within normality patterns, but worse thresholds in the smokers group compared to nonsmokers, both in conventional audiometry and in high frequency audiometry with statistically significant difference in both ears of the groups compared.
2	LILACS	Cigarette smoking as a risk factor for hearing loss	Occurrence of tinnitus in the groups of smokers was of 40.3% and of non-smokers was of 11.1%, having a statistically significant difference between the groups. In threshold tonal audiometry, the thresholds of the smokers group were worse for all frequencies than the non-smoking group, but were not statistically significant, except for the 8000Hz frequency in the left ear. In high frequency audiometry, smokers had worse thresholds for all frequencies, a statistically significant difference in the frequencies of 12500 Hz in the right ear and 14000 Hz in both ears. It was observed that in the group of smokers, 13.9% of those who reported tinnitus had no hearing loss with hearing thresholds within the normal range (<25dB) and in the non-smoking group, this occurred in 2.8% of subjects, statistically significant. EOAT, the smoker group had lower levels of response, and significant difference in the frequency of 1 kHz in both ears and the frequency of 4 kHz in the left ear and greater suppression of otoacoustic emissions.
3	LILACS	Prevalence of hearing loss and associated factors in the elderly population of Londrina, Paraná: preliminary study	There were no normal auditory thresholds in all individuals over the age of 70. Through the statistical test of Relative Risk, they verified that there is an absolute increase in the risk of hearing loss of 75.40% of individuals over 60 year of age. In 87.09% of individuals who had direct contact with smoking, hearing loss was found. When conducting the Relative Risk test, it was observed that smokers, ex-smokers and passive smokers with daily smoke exposure had a greater association with presence of hearing loss with 9 chances to have hearing loss, with a 77.42% increase in absolute risk.
4	LILACS	Comparative study of acoustic immittance measures in smokers and non-smokers	Smokers presented peak pressure significantly greater than the non-smoker group for both the right and left ears. For the other variables investigated (compliance values and tympanometric gradient) the tests indicated no statistical difference. The results obtained for all the immittance measures were within the normality standards considered by the authors of the study, presenting averages ranging from 0.89 to 0.98 ml for the equivalent volume of the external acoustic meatus (normality = 0, 6 to 1.5 ml); Between 0.55 and 0.71 ml for the static peak admittance (normality = 0.25 to 1.4 ml); Between 0.41 and 0.44 for the tympanometric gradient (normality = values equal to or above 0.2) and between -25.7 and -8 daPa for peak pressure (normality = values within the range of -100 to +50 daPa). Among the measures of acoustic immittance, the peak pressure of the tympanogram was the only parameter capable of differentiating smokers and non-smokers, and in the smokers, the pressure was increasingly shifted to negative.
5	LILACS	Auditory brainstem evoked potentials in smokers	The group of smokers had statistically higher I and V wave-latencies in the right ear, and V of the left ear compared to the non-smoker group. In addition, the group of smokers had III-V inter-latencies of both ears larger than those of the non-smoker group, but there was no significant difference between the groups. A significant difference was obtained in the absolute latency of wave I in the right ear and the V wave in both ear groups for smokers compared to the non-smoker group. An increase was also observed in III-V inter-latencies, which may indicate a high encephalic involvement in both ears for the smoker group.
6	MEDLINE	The Effect of Smoking on the Hearing Status -A Hospital-Based Study	With increasing age, the percentage of individuals with hearing threshold decreases was high, with higher percentages of smokers being affected compared to nonsmokers. In addition, when audiometry was performed in the 500 to 6000 Hz frequencies, the authors found high auditory thresholds in both smoking and nonsmoking groups. They classified the findings with degree and type of hearing loss, and 65.7% of smokers and 15% of nonsmokers had hearing loss. Mild hearing loss (26-40 dB) was the most common (56.5%), while severe hearing loss was the least common (2.8%) in smokers. In addition, 34.3% did not present hearing loss and 6.5% had moderate hearing loss, 77.5% were sensorineural, 4.2% conductive and 18.3% mixed. The severity of hearing loss in smokers increased with the increase in the number of cigarettes smoked and the smoking time, and this association was statistically significant.

T	Data base	Article Name	Results of hearing exams
7	MEDLINE	Cigarette smoking effect on human cochlea responses	Auditory thresholds were within normality patterns, but worse in smokers compared to nonsmokers, with statistically significant differences mainly in the frequency of 8 kHz. In the EOADP exam, the amplitude decreased in 1000, 2000, 4000 and 6000 Hz in the group of smokers, being statistically significant concerning the difference with the group of nonsmokers. EOAT presented decreased amplitudes, but without differences between groups. With the increase in the number of cigarettes, the thresholds worsened in the frequencies of 2000, 4000 and 8000 Hz, presenting a statistically significant difference. In the EOAT and EOADP, the number of cigarettes did not influence the results.
8	MEDLINE	Cigarette Smoking Causes Hearing Impairment among Bangladeshi Population	Hearing loss only on the threshold of 8000 Hz in the smoking group, but hearing thresholds of other higher frequencies in smokers compared to nonsmokers with significant statistical difference in the frequencies of 8000 and 12000 Hz. The smoking rate in this study (1 to> 20 ranges Of cigarettes / day) did not show significant impairment of hearing with the increase of the amount of cigarettes in the frequencies of 1000, 4000 and 8000 Hz, having statistically significant difference only in the frequency of 12 kHz.
9	MEDLINE	Otoacoustic Emissions in Smoking and Nonsmoking Young Adults	Auditory thresholds within the normal range. There was no significant difference in auditory thresholds between groups. In the EOAE response levels were higher up to 5 dB at certain frequencies in the ears of nonsmokers compared to smokers. This difference was most evident in the frequency range of 1 to 2 kHz. Altogether, the ears of smokers who presented with EOAE were 29, similar to non-smokers in which they were 32. Regarding the number of average cases / years, some smokers with greater values of packs / years did not present spontaneous otoacoustic emissions, however, there was a statistically significant difference compared to the group with fewer packs / years. In both groups, smokers and nonsmokers, the EOAT and EAOPD values of the ears without EOAE were smaller in comparison to the EOAE ears. These differences were more evident among smokers for both the EOAT response level and EAOPD. Regarding the EOAT, lower amplitude was found among smokers compared to non - smokers group with a significant difference in the frequency range of 1, 2 and 4 kHz. There was also a decrease in amplitude of EAOPD 1.4 kHz in the smoking group, with a statistically significant difference with the group of non - smokers. The results showed that there were no significant differences in EAOPD in relation to the number of cigarettes per year
10	MEDLINE	Effect of Cigarette Smoking and Passive Smoking on Hearing Impairment: Data from a Population-Based Study	Hearing loss was more evident in the groups aged 30 to 70, with the smoker group being more prevalent than the groups of passive and non-smokers, being a statistically significant difference. This also occurred when compared to the thresholds of the group of passive smokers and nonsmokers, in which the group of passive smokers presented worse thresholds than the other group.

Caption: EOAT and EOATE = otoacoustic emissions evoked by transient stimulus; EOADP = otoacoustic emissions evoked by distortion product; EOAE = spontaneous otoacoustic emissions

LITERATURE REVIEW

This article analyzes the scientific production concerning the effect of tobacco use in the peripheral auditory system and / or central nervous system; as various studies have hypothesized that cigarette smoking can cause hearing loss[1,4-8,11- 20].

After reviewing national and international literature, there are few observable studies that investigate the auditory system of smokers, especially when using smoking as an individual factor. There are several relevant studies that relate smoking to other agents, such as noise and chemicals, but these were not included in this review because of the exclusion criteria already presented. We believe that it will be increasingly difficult to compose samples with exclusivity to smokers, due to the association that exists with several factors. For example, cigarette smokers are commonly exposed to ethyl. However, the general population is also exposed to harmful physical agents, such as noise and pesticides. Also, drug users, and individuals with psychiatric and emotional disorders, can experience damage to the central nervous system, as well as those with metabolic and hormonal disorders.

It is worth mentioning that half of the studies analyzed were performed in Brazil. The other studies were from only three other countries worldwide, including one in the United States, shown in Table 1. Considering this, audiology appears to be well-researched in Brazil, as it represents half of the analyzed articles that met the inclusion criteria. In addition, we believe that the tobacco industry might play a role in the lack of articles from countries outside Brazil, as research may affect the future decisions of current smokers. It is also worth

considering that four of the surveys not performed in Brazil were done in a country with a lower income per capita (India), or in places with restricted access to information, such as Korea.

The literature review showed that all the publications found correspond to health and were published in magazines related to speech therapy [5,12,18] otolaryngology [4,13-15] diagnostics, [16] biomedicine, and medicine [17,19] . All articles had audiological diagnostics of smokers as a principal theme. Only one article featured research that included different factors within the same study, but the results did not interfere with the information concerning smokers[5].

The audiometry tonal threshold is considered the gold standard for obtaining thresholds and audiometric configuration in adults. Therefore, this has been used in all the articles found; some used this for comparison of hearing thresholds of smokers and nonsmokers [4,5,13-17,19] , and others only for application of the exclusion criteria, since individuals could not have thresholds above 25dBHL [12,18] . Only three studies used exclusively conventional tonal audiometry for hearing research [5,15,19] , and the others added other forms of evaluation. It was observed that the latest studies are those that used additional laboratory tests as a method of evaluation (as well as audiometry), probably due to the availability of high-value equipment. In other examples, without these additional methods of evaluation, the research protocol may not have been complete. In Europe and North America, complementary and otoneurogical exams are routine.

Regarding the results of the tests, conventional audiometry was found, and in the majority of articles, tonal thresholds were within normal standards [4,12-14,16,18]. Among these studies, some auditory thresholds in smokers were worse when compared to the thresholds of non-smokers, with a statistically significant difference [4,13,16] . There was only one study that presented no significant differences regarding the auditory thresholds between groups [14]. The others did not compare hearing thresholds between groups [12,18]. Four study groups, among those selected, found altered auditory thresholds [5,15,17,19] and one of them found hearing loss only in the frequency of 8000 Hz [17]. When compiling and analyzing all the results, it was observable that researchers found hearing threshold damage among smokers when compared to nonsmokers, even though there was no statistically significant difference, demonstrating that smoking is harmful to the auditory organ.

Among the studies that contained hearing thresholds within normal limits, the maximum age for featured subjects in the sample was 59 years old [12] and studies that had altered the hearing thresholds of the sample population included subjects up to 60 years old [15,17] and two with a maximum of up to 90 years old [5,19]. One such study only evaluated the hearing of the elderly, and featured individuals with more than 60 years of age with exposure to cigarette smoke and other factors [5], and the results showed no normal hearing thresholds in all subjects over the age of 70. However, the worse in that specific study was the group of smokers. One may assume that people over the age of 60, who were studied between the years of 2009 and 2016, grew up in an era where the act of smoking represented status. Advertising of the cigarette industry was much more pronounced when compared to recent years, and such advertising came without the indications of possible complications. Today, in Brazil and many other countries, it is mandatory to include in cigarette advertising some undesirable imagery concerning smoking and information about the negative effects, even on the pack of cigarettes bought at a store. It is also possible to observe the concern of the elderly today to maintain a healthy life, avoiding habits harmful to health such as smoking.

In high - frequency audiometry, results were similar to those of conventional audiometry, with thresholds within the normal range and worsening of thresholds in smokers, with a statistically significant difference between the groups of smokers and non-smokers in all studies that performed this test [4,13,16,17].

Another question related to the hearing of smokers is whether the number of cigarettes consumed would influence the results of hearing tests. Four articles studied this hypothesis [14-17] .In relation to the hearing thresholds, authors of two studies reported that there is worsening of thresholds as the number of cigarettes smoked increased[15,16]. However, other authors disagree with this theory [14,17], and one of such articles showed a worsening threshold in relation to the number of cigarettes consumed in only [17] the frequency of 12 kHz. It is known that, according to the time of exposure to the toxic agent, there is an increase in damages to health in general. Thus, it is expected that with the greater the number of cigarettes consumed and greater time of usage, the effects will only worsen. This likely applies to not only in the auditory system, but also throughout the body.

Among the selected articles, only one described tinnitus as an auditory symptom in the smoking group [4].

As seen in Table 3, some studies used otoacoustic emissions as a method [4,14,16] where the examination purpose is to evaluate the cochlear amplification mechanism (OHC). Regarding the otoacoustic emissions evoked by transient stimulus (ETEOE), two studies found decreased amplitudes in the group of smokers compared to nonsmokers [4,14]. And in another study, [16] no differences were found between groups. The difference in amplitude response between groups also occurred in the otoacoustic emissions, distortion product (DPOAE) [14,16]. Among the items studied, only one evaluated the olivocochlear system through the suppression effect. This presented, as a result, a greater suppression value in the smoking group [4.] Increased suppression in smokers is caused by the interference of nicotine in the neural transmission of auditory information, thus affecting the higher neural centers that may result effect in an inhibitory efferent in outer hair cells. This creates an acceleration effect on acetylcholine, which is the efferent neurotransmitter in the auditory system [20].

All the articles selected presented, as an exclusion criterion, the presence of alteration of the middle ear and/or previous otological diseases. In a few discarded hypotheses, studies performed immittanciometry [4,12,14,16,18]. Among these, only one study [18] aimed to compare the imitanciometry findings between groups of smokers and nonsmokers, and due to this, the sampled individuals should present hearing thresholds within the normal standards. The result of this study showed that the peak pressure tympanometry was the only parameter that could differentiate between smokers and nonsmokers. With smokers, the pressure was increasingly shifted to negative [18].

There are not many recent studies on the Auditory Brainstem Evoked Potential (BAEP) in the smoking population. When searching, only one study used the research of auditory brainstem response in the smoking population [12].The authors of this study hypothesized that tobacco use can cause high brain stem involvement, as there was an increase in latencies of I and V waves and of III-V inter-latencies in both ears of smokers. Therefore, it is concluded that tobacco may interfere with the neural transmission of auditory information, influencing the latencies and inter-latencies of the BAEP examination waves especially considering that this test has the capacity to evaluate the neurophysiological integrity of the auditory pathways of the brainstem.

With this knowledge, it is important to emphasize the importance of monitoring the hearing of smokers and the performance of diversified exams, mainly through the Evoked Otoacoustic Emissions Tests and the BAEP, as objective examinations that evaluate the functional integrity of the auditory system. Thus, they are able to identify possible alterations caused by cigarette smoking, and be used to provide caution and prevent the early auditory alteration caused by this harmful agent.

Presently, it can be observed that procedures, such as otoacoustic emissions, suppression effect, medium and long latency auditory, evoked performance potentials, favor the enrichment of the literature and diagnosis. We believe, however, that the composition of smoking groups with no association to other harmful agents in the current world population will remain difficult, due to the very characteristics of modern society. It is impossible, at present, to consider the existence of any study where otherwise healthy subjects start smoking for a period of time, exclusively for research. There are clear ethical standards for human studies, in-addition to moral conflicts that would likely arise with the researcher. One solution may be to carry out experimental studies.

CONCLUSION

All studies evaluated in the present review show data that imply that there is an increased risk of hearing loss in smokers. Several types of hearing evaluations were used in these individuals, allowing to make it possible to conclude that tobacco use influences the appearance of hearing loss, since auditory thresholds are worse with smokers. It is important to highlight that through the analysis of the articles, it is evident that the use of tobacco mainly affects the hair cells of the base of the cochlea, since the high frequencies are the most harmed. This result was also shown by the low level of response of evoked otoacoustic emissions, mainly by distortion product, which evaluates a frequency range higher than that of transient otoacoustic emissions.

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