COMPARATIVE STUDY OF ACOUSTIC IMMITTANCE IN SMOKERS AND NON-SMOKERS

Estudo comparativo das medidas de imitância acústicas em tabagistas e não tabagistas

Maria Cecília Carvalho Mourão[(1)], Heidi Elisabeth Baeck[(2)]

ABSTRACT

Purpose: to conduct a comparative study of the acoustic impedance measurements in smokers and nonsmokers, in order to identify the occurrence of specific behavior in the smoking population. **Methods:** in a sample of 80 individuals, namely 40 smokers and 40 nonsmokers, we obtained the outer acoustic meatus volume, the admittance, the peak pressure and the gradient**. Results:** the results showed that the peak pressure presented a significant difference between the groups, revealing itself more negative in the group of smokers, both for the right ear (p=0.004) and for the left ear (p=0.011). **Conclusion:** This study concludes that the peak pressure of the tympanogram is an immittance measure able to differentiate smokers and nonsmokers, where smokers show significantly more negative pressures.

KEYWORDS: Hearing; Smoking; Acoustic Impedance Tests

INTRODUCTION

In the past, advertising campaigns associated the habit of smoking with entertainment or status symbols, inducing a considerable number of people to the consumption of cigarettes, without due concern for their personal health. The reverse path has been taken for at least two decades, with government strategies that divulge the harm caused by smoking explicitly and broadly, within a global scope. Efforts towards provoking reflective thinking and the adoption of a preventive approach has resulted in more awareness in new generations, which still does not prevent that the smoking habit be considered one of the biggest challenges in public health, just like diabetes and arterial hypertension.

Brazil is a successful case in the fight against smoking, revealing a 50% drop in the rate of smoking in the past twenty years[1]. However, in the country, there are 25 million smokers starting at the age of 15[2]. These high statistics are not a national exclusivity. About 20 % of adults in the United States are smokers[3]. A global estimate points out that 100,000 youngsters start smoking every day[4].

The ambition to reduce figures of such proportions has been motivating groups of researchers who have smoking as their object of study. While it may be a global trend to do research in the line of “factors associated with the rates of interruption of the smoking habit”[1,5,6] and the effect of public policies on tobacco control [1,7,8], base research focusing on the knowledge of associations between smoking and its users’ health impairments remains relevant and current.

Various diseases and chronic conditions are systematically associated with smoking and the dysfunctions of the auditory system are part of these diseases[9,10]. Based on the findings that over 4.720 toxic components are blended to tobacco nicotine, the ototoxic power of cigarettes has supported the hypothesis of the correlation between smoking and impairment of the inner ear, namely, vestibular, cochlear and retrocochlear [10-13].

It is natural that most of the researchers conduct their studies in order to investigate the inner ear as, characteristically, the ototoxicity affects this structure specifically. However, it is observed that

(1) University Veiga de Almeida (UVA), Rio de Janeiro, RJ, Brazil.

(2) University Veiga de Almeida (UVA), Rio de Janeiro, RJ, Brazil.

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in related literature, studies indicate the evidence that nicotine and other toxic substances contained in cigarettes cause histopathological changes in the respiratory lining tract[14]. Given that the mucosa lining the middle ear has the same characteristics of the respiratory tract[15] , the hypothesized relationship between smoking and middle ear impairment deserves to be investigated.

It is widely known that in audiology practice, the investigation of the middle ear is accomplished by obtaining the acoustic immittance measurements and, despite the simplicity of this procedure, such measurements are of great importance in the evaluation of hearing disorders[16]. As the effect of tobacco in the middle ear is the focus of this paper, the present study conducted a comparative study of the acoustic impedance measurements in smokers and nonsmokers in order to identify the occurrence of a specific pattern in the smoking population.

METHODS

The current research was conducted in the Department of Audiology, at the University Hospital Antônio Pedro (HUAP) affiliated to the Fluminense Federal University (UFF) in Niterói - RJ. The research is a cross-sectional, observational and descriptive exploratory study, approved by the Ethics Committee of the University Veiga de Almeida / Platform Brazil (No.01492312.3000.529).

The sample consisted of 80 participants, being 40 smokers and 40 nonsmokers. Smokers were selected among individuals who were members of the HUAP Project Against Tobacco Use, under the following inclusion criteria: consumption of five or more cigarettes per day and being a user for at least one year. Nonsmokers were selected at random under the criterion of never having smoked or lived with smokers.

After following ethical procedures, participants underwent previous procedures: interview, otoscopy, pure tone threshold audiometry and speech audiometry. Exclusion criteria were applied to obtain a sample exempt from auditory impairment of other types.

Interview: An interview was conducted individually by a speech pathologist. It is a structured interview aiming to collect registration data and data on smoking and history of alterations in acute or chronic ear and respiratory system. Participants who answered yes to any item of the interview which referred to previous problems of middle ear diseases were excluded.

Otoscopy: The exam was done at the Otorhinolaryngology, in order to check the integrity of the anatomical structures of the external and middle ear. In case of excessive earwax, a removal was performed and the participant was kept in the research. Participants with medical record showing alterations were excluded.

Pure tone threshold audiometry: This test was performed by the speech pathologist, in a soundproof booth SIMBELMED AC75D audiometer and TDH - 50 phones. Pure tone air-conduction thresholds were assessed at frequencies 250, 500, 1000, 2000, 3000 and 4000 kHz. Participants who had one or more thresholds > 25 dB HL were excluded.

Speech Recognition Threshold (SRT): This exam sought confirmation of air conduction thresholds. Participants who had incompatible SRT were excluded, having been accepted as compatible participants with values equal to with deviation of up to 10 dB HL average tritone (500, 1000 and 2000 Hz).

Audiometric data and SRT of participants who were not excluded are described in both the smoking group (Tables 1 and 2) and the non-smoking group (Tables 3 and 4).

Table 1 – Audiometric thresholds and speech recognition in right ear of the smoking group (n=40)

	Audiometric Thresholds						SRT
	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	
Participant 01	25	25	20	20	10	10	20
Participant 02	10	10	10	15	10	10	10
Participant 03	25	20	20	20	15	15	20
Participant 04	20	20	15	20	20	25	20
Participant 05	15	15	25	20	25	25	20
Participant 06	20	20	20	15	15	20	20
Participant 07	25	20	15	15	20	15	20
Participant 08	20	20	15	10	20	25	20
Participant 09	20	20	20	15	15	10	20
Participant 10	25	25	10	20	10	15	20
Participant 11	25	25	25	25	25	25	25
Participant 12	25	20	20	15	15	15	20
Participant 13	20	15	15	10	10	15	15
Participant 14	25	25	20	15	20	25	20
Participant 15	25	20	20	10	20	20	20
Participant 16	15	15	15	15	20	15	15
Participant 17	20	15	15	15	20	25	15
Participant 18	25	20	20	10	10	10	10
Participant 19	20	20	15	15	10	10	15
Participant 20	20	20	15	15	15	15	15
Participant 21	25	20	20	10	15	25	10
Participant 22	25	25	25	25	25	25	25
Participant 23	15	10	10	5	5	20	10
Participant 24	20	20	20	10	15	20	20
Participant 25	25	20	25	25	25	25	20
Participant 26	20	20	15	5	10	10	15
Participant 27	20	20	15	15	10	10	15
Participant 28	20	15	15	5	5	10	10
Participant 29	15	15	15	10	10	10	15
Participant 30	15	10	20	10	10	15	15
Participant 31	20	15	20	15	15	20	15
Participant 32	20	15	10	5	15	20	10
Participant 33	25	20	20	15	10	15	15
Participant 34	20	15	15	15	10	20	15
Participant 35	25	20	15	15	15	20	15
Participant 36	25	25	25	25	25	25	25
Participant 37	20	20	20	20	20	20	20
Participant 38	15	15	15	15	15	15	15
Participant 39	25	20	20	15	25	25	20
Participant 40	20	20	10	10	05	05	10

SRT: Speech Recognition Threshold (compatible with the audiometric threshold)

Table 2 – Audiometric thresholds and speech recognition in left ear of the smoking group (n=40)

	Audiometric Thresholds						SRT
	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	
Participant 01	25	20	20	15	15	15	20
Participant 02	10	10	15	15	15	15	15
Participant 03	25	25	20	20	15	15	20
Participant 04	20	20	15	20	25	25	20
Participant 05	15	15	10	10	15	15	10
Participant 06	20	20	10	10	15	20	15
Participant 07	25	20	15	15	20	20	15
Participant 08	25	25	10	10	15	15	15
Participant 09	20	20	15	15	15	20	20
Participant 10	25	25	15	10	10	15	15
Participant 11	25	20	20	25	25	20	20
Participant 12	25	25	15	15	20	20	20
Participant 13	20	15	15	10	10	10	15
Participant 14	25	25	20	15	20	25	20
Participant 15	25	20	20	10	15	20	15
Participant 16	15	15	15	20	20	20	15
Participant 17	20	15	10	10	20	25	10
Participant 18	20	20	15	10	10	15	10
Participant 19	20	20	15	10	10	10	15
Participant 20	25	20	20	15	15	15	20
Participant 21	25	20	10	15	15	35	15
Participant 22	25	25	20	25	25	25	20
Participant 23	20	15	10	5	10	15	10
Participant 24	25	20	20	20	20	15	20
Participant 25	25	20	15	15	20	20	15
Participant 26	20	20	15	5	10	10	15
Participant 27	25	20	15	10	10	15	15
Participant 28	20	20	15	10	15	10	15
Participant 29	15	15	15	10	10	15	15
Participant 30	25	25	10	5	5	5	10
Participant 31	15	15	15	10	10	10	15
Participant 32	20	15	15	10	10	10	15
Participant 33	20	20	15	10	15	20	15
Participant 34	25	20	10	10	20	25	15
Participant 35	25	25	20	10	10	10	20
Participant 36	25	25	15	15	25	25	20
Participant 37	25	20	20	15	20	20	15
Participant 38	15	15	15	15	15	10	15
Participant 39	20	25	20	15	10	10	20
Participant 40	20	15	15	10	5	5	10

SRT: Speech Recognition Threshold (compatible with the audiometric threshold)

Table 3 – Audiometric thresholds and speech recognition in right ear of the non-smoking group (n=40)

	Audiometric Thresholds						SRT
	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	
Participant 01	10	10	10	5	5	10	10
Participant 02	15	15	15	10	5	5	15
Participant 03	10	10	10	5	5	10	10
Participant 04	20	15	15	15	10	10	15
Participant 05	20	20	20	10	10	15	15
Participant 06	15	15	10	15	20	25	10
Participant 07	15	15	15	10	15	10	15
Participant 08	25	25	25	10	10	10	20
Participant 09	15	15	15	10	5	10	15
Participant 10	20	20	15	10	10	15	15
Participant 11	15	15	15	10	15	10	15
Participant 12	25	20	15	15	20	20	15
Participant 13	20	15	15	10	5	10	10
Participant 14	15	15	15	20	10	15	15
Participant 15	20	20	20	20	20	10	20
Participant 16	20	20	15	15	10	10	15
Participant 17	15	20	15	15	20	20	15
Participant 18	20	15	15	15	15	10	15
Participant 19	15	20	15	15	15	25	15
Participant 20	20	15	15	10	10	25	15
Participant 21	25	20	15	15	10	20	15
Participant 22	25	20	20	15	10	15	20
Participant 23	10	15	15	20	15	15	15
Participant 24	15	15	15	20	20	15	15
Participant 25	25	25	20	20	20	15	20
Participant 26	20	15	15	15	15	15	15
Participant 27	25	20	20	20	25	20	20
Participant 28	20	20	15	15	15	15	15
Participant 29	20	20	20	20	15	15	20
Participant 30	20	15	15	20	10	10	15
Participant 31	25	25	25	15	10	10	20
Participant 32	20	20	20	20	20	15	20
Participant 33	15	10	10	10	5	5	10
Participant 34	20	20	20	10	15	20	15
Participant 35	20	15	20	20	15	15	20
Participant 36	20	15	15	10	15	15	15
Participant 37	25	20	15	10	10	10	15
Participant 38	20	15	15	10	15	5	15
Participant 39	25	20	20	20	15	25	20
Participant 40	15	10	10	5	5	10	10

SRT: Speech Recognition Threshold (compatible with the audiometric threshold)

Table 4 – Audiometric thresholds and speech recognition in left ear of the non-smoking group (n=40)

	Audiometric Thresholds						SRT
	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	
Participant 01	20	15	10	5	10	10	10
Participant 02	15	15	15	5	5	5	10
Participant 03	15	10	10	5	5	5	10
Participant 04	15	10	10	10	10	10	10
Participant 05	20	15	15	10	20	10	15
Participant 06	15	15	10	10	20	25	10
Participant 07	15	15	10	10	10	10	10
Participant 08	20	15	15	10	5	5	15
Participant 09	15	10	15	10	10	15	10
Participant 10	20	15	15	15	10	10	15
Participant 11	15	15	10	10	10	10	15
Participant 12	25	20	15	10	15	10	15
Participant 13	15	10	10	10	10	10	10
Participant 14	15	10	15	15	10	10	15
Participant 15	25	20	20	20	15	15	20
Participant 16	20	20	15	10	15	15	15
Participant 17	20	20	10	10	10	15	10
Participant 18	20	15	10	15	20	15	10
Participant 19	20	15	15	15	20	25	15
Participant 20	25	20	15	10	15	15	15
Participant 21	25	20	15	10	5	5	15
Participant 22	25	20	20	15	10	15	20
Participant 23	15	15	15	15	15	15	15
Participant 24	15	15	10	10	15	10	10
Participant 25	25	25	15	15	20	15	15
Participant 26	20	20	15	10	15	15	15
Participant 27	25	20	20	20	20	15	20
Participant 28	15	20	15	15	15	15	15
Participant 29	20	15	15	10	10	15	15
Participant 30	20	15	15	20	15	15	15
Participant 31	25	20	20	15	15	20	20
Participant 32	25	20	15	15	20	15	15
Participant 33	15	15	10	5	5	5	10
Participant 34	15	20	20	15	15	20	20
Participant 35	20	20	20	25	25	20	20
Participant 36	15	15	15	10	15	15	15
Participant 37	20	15	15	10	10	10	15
Participant 38	15	15	15	15	10	15	15
Participant 39	25	25	20	20	15	15	20
Participant 40	20	15	10	5	5	5	10

SRT: Speech Recognition Threshold (compatible with the audiometric threshold)

The research procedures themselves, refer to obtaining the quantitative acoustic immittance measures: equivalent volume of the external acoustic meatus; static admittance peak; pressure peak of the tympanogram, and tympanometric gradient. (With the aid of immittanciometer AMPLAID A 750 and a 226 Hz probe).

The statistical analysis was conducted in order to describe the sample, compare right and left ears and finally compare the smoking and non-smoking groups.

For characterization purposes, numerical variables were expressed by their measures of central tendency (median, standard deviation), while categorical variables were expressed by frequencies (n) and percentage (%) For comparison purposes, the methods used were the Wilcoxon Signed-Rank Test, for the analysis of right and left ears, and the Mann-Whitney test for the analysis of smoking and nonsmoking groups. The criterion for determining significance adopted was level 5 % ($p \leq 0.05$). We opted for non-parametric tests due to rejection of the hypothesis of data normality of Kolmogorov-Smirnov test. The analysis mentioned were performed with the aid of the Statistical Analysis System SAS 6.11 program (SAS Institute, Inc., Cary, NC)

RESULTS

The group of smokers had an average age of 45.7 years (± 10.5), with a higher prevalence of females (75 %) than males (25 %). The participants' length of smoking time averaged 23.7 years (± 10.3), with an average of 20.8 (± 7.5) cigarettes / day. The non-smoker group average age was 40 years (± 11.9) and, like the group of smokers, it had a higher prevalence of females (72.5%) than males (27.5%).

Below, there is a the description of the findings related to immittance measurements for smokers (Table 5) and nonsmokers (Table 6). Once the comparison between right and left ears showed a statistically significant difference in the 'equivalent volume' (Table 7), the comparative analysis between the smoking and non-smoking groups (Table 8) was performed separately for each ear.

Insert Tables 5,6,7 and 8.

The results showed that smokers had a significantly higher peak pressure than the non-smoking group, both for the right and the left ear. For the other variables investigated, test indicated no statistical differences (Table 8)

Table 5 – Acoustic Immittance Measurements in the smoking group (n=40)

	Right Ear				Left Ear			
	EV_{EAM}	SPA	PPT	TG	EV_{EAM}	SPA	PPT	TG
Participant 01	0,77	0,64	4,00	0,50	0,85	0,91	2,00	0,54
Participant 02	0,79	0,55	-10,00	0,22	1,24	0,4	-12,00	0,26
Participant 03	1,35	0,26	-28,00	0,30	1,33	0,25	-12,00	0,34
Participant 04	0,81	0,29	-45,00	0,23	0,89	0,30	-55,00	0,26
Participant 05	0,82	0,89	-26,00	0,44	0,96	0,40	18,00	0,24
Participant 06	1,31	0,39	-6,00	0,33	1,43	0,46	0,00	0,39
Participant 07	0,65	0,82	-4,00	0,52	1,05	0,76	-18,00	0,57
Participant 08	1,16	0,35	-6,00	0,38	1,25	0,25	4,00	0,33
Participant 09	1,96	1,37	-8,00	0,25	1,06	1,06	-12,00	0,57
Participant 10	0,92	0,28	-58,00	0,44	0,75	0,36	-14,00	0,36
Participant 11	0,81	0,53	-12,00	0,41	0,93	0,25	-12,00	0,42
Participant 12	0,48	0,31	-2,00	0,25	0,45	0,33	-1,00	0,29
Participant 13	0,75	0,32	-22,00	0,33	0,79	0,35	-26,00	0,33
Participant 14	1,52	0,76	-10,00	0,51	1,27	0,61	-18,00	0,49
Participant 15	0,71	0,84	-80,00	0,53	0,96	0,62	-4,00	0,45
Participant 16	1,27	0,86	-24,00	0,44	1,43	0,95	-20,00	0,47
Participant 17	0,82	0,95	-10,00	0,57	0,93	0,88	-6,00	0,63
Participant 18	0,91	0,93	-38,00	0,42	0,98	0,90	-36,00	0,39
Participant 19	1,14	0,66	-150,00	0,55	1,14	0,75	-12,00	0,45
Participant 20	0,93	1,18	-76,00	0,51	1,06	0,86	-30,00	0,45
Participant 21	0,85	2,08	-44,00	0,60	0,83	1,39	-28,00	0,51
Participant 22	1,16	0,48	-12,00	0,32	1,15	0,57	-44,00	0,23
Participant 23	0,67	0,70	-18,00	0,51	0,77	1,14	-15,00	0,66
Participant 24	0,88	0,40	-16,00	0,36	0,90	0,36	-32,00	0,24
Participant 25	0,85	0,38	-4,00	0,52	1,17	0,74	-4,00	0,54
Participant 26	1,21	0,16	-35,00	0,26	1,16	0,58	-55,00	0,48
Participant 27	0,6	0,4	-14,00	0,30	0,65	0,6	-16,00	0,35
Participant 28	0,73	2,30	0,00	0,54	0,55	3,80	-14,00	0,22
Participant 29	1,35	1,25	-16,00	0,65	1,31	1,46	-10,00	0,20
Participant 30	1,01	0,46	-12,00	0,22	0,96	0,35	-2,00	0,33
Participant 31	0,85	0,25	-95,00	0,22	0,94	0,4	-5,00	0,30
Participant 32	0,95	0,45	-14,00	0,40	0,80	0,82	-26,00	0,75
Participant 33	0,88	0,40	-14,00	0,31	0,97	0,45	-70,00	0,45
Participant 34	0,81	1,40	2,00	0,60	0,79	1,00	-10,00	0,56
Participant 35	0,71	0,79	-22,00	0,51	0,75	0,95	-32,00	0,49
Participant 36	1,26	0,45	0,00	0,40	1,16	0,28	2,00	0,34
Participant 37	0,63	0,70	-12,00	0,44	0,63	0,81	-3,00	0,37
Participant 38	1,14	0,52	-60,00	0,40	1,5	0,48	-2,00	0,33
Participant 39	0,84	0,61	-12,00	0,48	0,75	0,52	-14,00	0,45
Participant 40	0,59	0,29	-18,00	0,24	1,00	0,38	-18,00	0,41
Median	**0,94**	**0,69**	**-25,7**	**0,41**	**0,98**	**0,71**	**-16,6**	**0,41**
Standard Deviation	0,29	0,46	3,8	0,12	0,24	0,58	17,6	0,13

EV_{EAM}: equivalente volume of external acoustic meatus; SPA: static peak admittance;
PPT: pressure peak of tympanogram; TG: tympanometric gradient.

Table 6 – Acoustic Immittance Measurements in the non-smoking group (n=40)

	Right Ear				Left Ear			
	EV_{EAM}	SPA	PPT	TG	EV_{EAM}	SPA	PPT	TG
Participant 01	0,86	0,62	0,00	0,45	0,85	0,54	0,00	0,27
Participant 02	0,70	0,53	-10,00	0,51	0,79	0,63	0,00	0,54
Participant 03	1,01	0,77	-4,00	0,46	1,03	0,61	-4,00	0,43
Participant 04	1,04	0,63	-28,00	0,43	1,14	0,65	-22,00	0,45
Participant 05	1,29	0,80	-14,00	0,47	1,03	0,87	-8,00	0,28
Participant 06	0,85	0,30	-26,00	0,38	1,09	0,39	-20,00	0,36
Participant 07	0,81	0,38	0,00	0,44	0,95	0,40	0,00	0,39
Participant 08	1,28	0,45	-10,00	0,38	1,19	0,50	-8,00	0,54
Participant 09	1,10	0,36	-27,00	0,34	1,18	0,53	-26,00	0,57
Participant 10	0,85	0,56	-15,00	0,54	0,84	0,61	-10,00	0,52
Participant 11	1,02	0,57	-8,00	0,48	1,08	0,51	-8,00	0,42
Participant 12	1,01	0,37	0,00	0,34	1,02	0,46	0,00	0,41
Participant 13	0,82	0,59	-14,00	0,50	0,86	0,44	-18,00	0,37
Participant 14	0,93	0,57	-6,00	0,45	0,57	0,62	-5,00	0,42
Participant 15	0,71	1,00	0,00	0,65	0,83	0,89	0,00	0,52
Participant 16	0,80	0,72	0,00	0,4	0,82	0,60	0,00	0,4
Participant 17	0,82	0,40	-14,00	0,42	0,91	0,55	-18,00	0,46
Participant 18	0,82	0,54	0,00	0,80	1,31	0,70	0,00	0,42
Participant 19	0,94	0,53	0,00	0,43	0,96	0,77	0,00	0,52
Participant 20	0,63	0,44	0,00	0,40	0,64	0,41	0,00	0,39
Participant 21	0,68	0,88	-5,00	0,56	0,61	0,69	-2,00	0,42
Participant 22	0,88	0,58	-36,00	0,5	1,61	0,84	-14,00	0,36
Participant 23	0,85	0,31	-16,00	0,33	0,82	0,25	-12,00	0,36
Participant 24	0,71	0,47	0,00	0,40	0,72	0,40	0,00	0,40
Participant 25	1,16	0,49	-20,00	0,44	1,23	0,56	-26,00	0,39
Participant 26	0,68	0,41	0,00	0,37	0,83	0,40	0,00	0,41
Participant 27	1,36	0,45	-26,00	0,27	1,02	0,56	-20,00	0,43
Participant 28	1,27	0,39	-10,00	0,39	1,29	0,44	-4,00	0,43
Participant 29	1,25	0,25	-12,00	0,20	1,74	0,27	-14,00	0,24
Participant 30	0,57	0,38	0,00	0,41	0,56	0,44	0,00	0,41
Participant 31	0,87	1,30	-26,00	0,56	1,41	1,40	-24,00	0,29
Participant 32	0,76	0,42	-22,00	0,49	0,72	0,62	-14,00	0,51
Participant 33	1,33	0,44	-3,00	0,33	1,03	0,42	-3,00	0,33
Participant 34	0,78	0,29	0,00	0,32	0,70	0,39	0,00	0,35
Participant 35	0,92	0,68	-6,00	0,67	0,99	0,47	-4,00	0,41
Participant 36	0,94	0,82	-25,00	0,53	1,07	0,49	-28,00	0,44
Participant 37	0,31	0,32	0,00	0,23	0,38	0,27	0,00	0,27
Participant 38	0,96	0,55	-8,00	0,41	1,75	0,88	-6,00	0,63
Participant 39	0,58	0,47	0,00	0,34	0,43	0,68	0,00	0,4
Participant 40	0,72	1,20	0,00	0,61	0,70	1,00	0,00	0,53
Median	**0,89**	**0,55**	**-9,8**	**0,44**	**0,96**	**0,57**	**-8,0**	**0,41**
Standard Deviation	0,23	0,23	10,5	0,11	0,31	0,22	9,1	0,08

EV_{EAM}: equivalent volume of external meatus; SPA: static peak admittance;
PPT: pressure peak of tympanogram; TG: tympanometric gradient.

Table 7 - *p*-Value of comparative analysis between right and left ears

Variable	*p-value*
Equivalent Volume (ml)	**0,008***
Static Admittance (ml)	0,36
Pressure Peak (daPa)	0,09
Gradient	0,53

* statistical significance (p>0,05); Wilcoxon signed-rank test

Table 8 - *p*-Value of comparative analysis between smoking and non-smoking groups

Variable	*p-value*
Equivalent Volume (ml) RE	0,79
Equivalent Volume (ml) LE	0,59
Static Admittance (ml) RE	0,46
Static Admittance (ml) LE	0,62
Pressure Peak (daPa) RE	**0,004***
Pressure Peak (daPa) LE	**0,011***
Gradient RE	0,41
Gradient LE	0,63

* statistical significance (p>0,05); Mann-Whitney Test

DISCUSSION

The convenience sample showed a prevalence of the female gender. This finding does not corroborate national epidemiological research pointing to the smoking population as being predominantly male, in most of the Brazilian territory[17]. However, it is in accordance with the predominantly female characterization (73 %) of an on-demand research, in which the investigated population consisted not only of smokers, but also of smokers seeking help to quit smoking[18], which is similar to the population analyzed in the current study. The female predominance (70 %) in the group of smokers treated at University Hospital Antônio Pedro (HUAP) had already been identified in a previous study that investigated the Auditory Evoked Potential in smokers[13]. The discrepancy in the characterization of the gender of smokers among the population surveys and on-demand (developed in recovery programs) would suggest that, despite being minor tobacco consumers, women have greater health concerns, which confirms the overall clinical practice at HUAP empirically showing a more frequent presence of women.

As for the variables directly associated with smoking, the large variability obtained in both the length of smoking time, and the number of cigarettes/day stands out. The minimum length of smoking time was five years while the maximum was 40 years, indicating an interval of 35 years. With regard to the 'number of cigarettes/day', a minimum of four and a maximum of 40 cigarettes were obtained, showing a variation of 36 cigarettes per day.

Literature reports that regular smoking for more than a year is already enough to cause hearing damage[11]; therefore, all participants in this study are potentially harmed, having a methodologically appropriate sample. However, it is also mentioned that the toxicity of cigarettes is directly proportional to its consumption[10], showing that less expressive variables in the characteristics of smoking may prove to be interesting in future studies which investigate the smoking population .

In the current research, there was no concern to subdivide the sample according to age or gender, since the literature that involves patterns of audiology testing indicate that the variation of acoustic immittance measurements are not dependent on the participants' age variation or gender. A study with 91 participants, which investigated the equivalent volume of the external acoustic meatus, showed absolute values slightly higher for males (2.04 ml to 2.01 ml left ear and right ear) in comparison to females (1.81 ml in the left ear and right ear to 1.79 ml), but the statistical analysis comparing age groups and genders showed no significant difference[19]. We referred to the same findings with respect to investigations of admittance and tympanic gradient, since the comparative analysis between age groups and genders male and female did not confirm statistically significant differences for any of these two measurements of acoustic immittance[19].

In the previous procedures, the exclusion criteria were carefully determined. This study intended to observe the toxic effect of tobacco in the middle ear, and therefore, it somehow needed to neutralize other potentially harmful factors to that structure. If the exclusion criteria were not so strict, it could jeopardize the sample with individuals with conductive otological diseases, imposing a bias to the research. There are at least two developments regarding this issue that deserve comments: the requirement of normal audiometric thresholds and tonal restriction in the audiometry (250-4000 Hz).

Literature indicates that the habit of smoking is a risk factor for hearing. In methodologically diversified research, otoacoustic emissions[20], evoked otoacoustic potentials[12,13] or audiometric thresholds[9,10] smokers showed significant worse results compared to nonsmokers. This is, selecting, only patients with normal audiological evaluation for this study may seem to be a methodological inconsistency, at the risk of the population of interest (smokers with damage of the middle ear as a result of tobacco use) not being represented in the sample . The choice for selection criteria favoring auditory patterns of normality is justified by the pursuit to control the origin of the middle ear impairment occasionally observed in participants. If , with the requirement of normal thresholds we took the risk of not having the population of interest represented in the sample, the exemption of such criteria might generate a sample contaminated by conductive alterations of sources other than smoking, imposing a bias that we, authors of this study, considered more severe than those imposed by the “less representative” sample. In the comparative analysis of immittance measurements between smokers and nonsmokers, the insufficient sample could result in inadequate acceptance of the null hypothesis (not signaling differences when in fact they do exist); however, a contaminated sample could result in improper rejection of the null hypothesis (signaling differences when in fact they do not exist).

The requirement of normal audiometric thresholds was limited to those of 250 to 4,000 Hz. We observed a tonal restriction, in which we eliminated the evaluation of frequencies 6000 and 8000 Hz. Downgrades in those frequencies are not typically associated with middle ear impairment, which is the target of the sample control; therefore, exclusion criteria extended to them could not be justified.

The results obtained for all immittance measurements proved consistent with the normality values presented in the literature[15]. Observing both ears in both groups, the findings showed averages ranging from 0.89 to 0.98 ml for the equivalent volume of the external acoustic meatus, converging the normal pattern described in literature 0.6 to 1.5 ml, between 0.55 and 0.71 ml for peak static admittance converging the normal standard literature from 0.25 to 1.4 ml, between 0.41 and 0.44 for the tympanometric gradient, according to literature which suggests values equal or above 0.2 and finally between -25.7 and -8 daPa for pressure peak, corroborating the literature which considers values within the range -100 to +50 daPa as normal.

It was expected that the findings would agree with the literature, as the sample was composed of individuals with normal audiometric curves. The hypothesis of identifying a behavior of variables specific to smokers was about possible variations within the pattern of normality.

In the comparative analysis between smokers and nonsmokers, the pressure peak proved to be a variable that provides information. Differences were identified between the groups investigated both verified both for the right ear (p = 0.004) and left ear (p = 0.001). It can be observed that in smokers the peak shifts for negative pressure was higher (-25.7 daPa to the right and -16.6 daPa to the left), in relation to non-smokers (-9.8 daPa to the right ear and -8.0 daPa to the left). With regards to the alterations in the tympanogram, the type C curve refers to the curve that presents the maximum compliance peak shifted to negative pressure and it is said to be compatible with tubal dysfunction[18], therefore, the highest negative pressure observed in the group of smokers could be attributed to a tubal issue.

In a way, it would be an anticipation to affirm that the tobacco toxin would be responsible for tubal dysfunctions of participants in this study, since the etiology of tubal problems is diverse and not all the possible causes of it could be controlled. Furthermore, it would be considered inappropriate to consider suggestive tubal dysfunction pressures that have moved on average only -25.7 to the right and -16.6 daPa to the left. However, it is intriguing, to say the least, that despite excluding allergic reactions and infections of the upper airways, which reportedly refer to the most common causes of tubal dysfunction, the pressure peak has been shown to be statistically more negative for smokers specifically.

Assuming that the findings suggest that there is an indication of tubal dysfunction in smokers, it can be stated that the present results prove to be consistent with histopathological findings that, in smokers, there is a decreased beating of the hair cells of the hearing tube mucosa[21]. Likewise, research on guinea pigs, which showed that tobacco smoke exposure alters the Eustachian tube, contributing to the development of otitis media[22,23] corroborate the findings, as well as research in humans which indicated passive smoking as a predominant risk factor for recurrent otitis in children [24-26].

No significant differences were found in the comparative analysis of the other variables investigated: equivalent volume of external acoustic meatus, static admittance of peak and gradient, indicating that they do not provide information about the habit of smoking.

The results of this research are still seminal; however, the conservative criteria in the sample composition provide relative consistency to the findings. Future studies with larger samples and with longitudinal follow- up of the pressure peak of the tympanogram may deepen the knowledge about the toxic effect of tobacco on the functioning of the Eustachian tube.

CONCLUSION

Based on the findings, the present study ascertained that, among the acoustic immittance measurements, the pressure peak of the tympanogram is the only parameter able to differentiate smokers from nonsmokers, and for smokers the pressure is shifted to negative.

RESUMO

Objetivo: realizar um estudo comparativo das medidas de imitância acústica em tabagistas e não tabagistas, visando identificar a ocorrência de um comportamento específico na população tabagista. **Métodos:** em uma amostra 80 indivíduos, 40 tabagistas e 40 não tabagistas, foram obtidos o volume do meato acústico externo, a admitância, a pressão de pico e o gradiente. **Resultados:** os resultados mostraram que pressão de pico apresentou diferença significante entre os grupos, revelando-se mais negativa no grupo dos tabagistas, tanto para a orelha direita (*p*=0,004) quanto para a esquerda (*p*=0,011). Nas demais medidas investigadas não foram verificadas diferenças estatísticas. **Conclusão:** Desta forma, o presente estudo conclui que a pressão do pico do timpanograma é uma medida imitanciométrica capaz de diferenciar tabagistas e não tabagistas, sendo que nos tabagistas a pressão mostra-se significantemente mais negativa.

DESCRITORES: Audição; Tabagismo; Testes de Impedancia Acustica

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Mailing address:
Maria Cecília carvalho Mourão
Rua Dr. Alcides Figueiredo 30 aptº 302
Centro – Niterói – RJ
CEP: 24020-230
Email: mceciliamourao@gmail.com