

School auditory profile analysis

Análise do perfil audiométrico de escolares

Analisis del Perfil Audiométrico de Escolares

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ABSTRACT

Introduction: The identification of hearing problems in schools makes it possible to plan and promote hearing health and to prevent hearing disorders. **Aim:** To evaluate children's hearing in a public elementary school. **Method:** This is contemporary cross-sectional cohort study. Pure-tone audiometry test was done on 406 students from 1st to 4th grade in a public elementary school. An audiological evaluation was performed at the school with a MAICO MA41 audiometer, in a soundproof booth. **Results:** Among the 406 children tested, 50 (12.3%) had hearing loss in one or both ears, on one or more frequencies, with the worst average thresholds at the frequency of 6000 Hz with hearing loss happening in the right ear 51.7% of the time, and 356 children (87.7%) had normal results. **Conclusion:** We conclude that the hearing tests carried out inside of schools is valid for the detection of hearing loss. Because 24% of the children had hearing loss, it is important to develop prevention programs for auditory health. Based on other results also found in this study, i.e., thresholds lower than 6000 Hz, more attention needs to be given to increasingly early auditory habits that children are developing.

Keywords: Hearing, Audiometry, Pure-Tone; Students; Habits.

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RESUMO

Introdução: A identificação de problemas auditivos nas escolas torna possível a elaboração de ações de promoção da saúde auditiva e de prevenção de alterações auditivas. **Objetivo:** Avaliar a audição de crianças de uma escola pública de Ensino Fundamental I. **Material e Método:** Forma de estudo: Estudo de coorte contemporânea com corte transversal. Foi realizada audiometria tonal limiar em 406 alunos da 1ª a 4ª série de uma escola pública de ensino Fundamental I. A avaliação audiológica foi realizada na escola com audiômetro MAICO MA41, em cabina acústica. **Resultados:** Entre as 406 crianças, 50 (12,3%) apresentaram alterações auditivas em uma ou ambas as orelhas, em uma ou mais frequências, sendo as piores médias de limiares na frequência de 6000 Hz com alterações em 51,7% das orelhas direitas e 356 crianças (87,7%) obtiveram resultados normais. **Conclusões:** A avaliação auditiva em escolares, dentro da própria escola é válida para a detecção de perdas auditivas. Pelo fato de 24% das crianças terem apresentado alterações, impõem-se o desenvolvimento de programas de prevenção em saúde auditiva, Frente aos resultados também encontrados neste estudo, ou seja, piores limiares em 6000 Hz faz-se necessária maior atenção aos hábitos auditivos que as crianças vêm desenvolvendo, cada vez mais precocemente.

Palavras-chave: Audição; Audiometria de Tons Puros; Estudantes; Hábitos.

Resumen

Introducción: la identificación de problemas auditivos en escuelas hace posible la elaboración de acciones de promoción de la salud y de la prevención de alteraciones auditivas. **Objetivo:** evaluar la audición de niños de una escuela pública de Enseñanza Fundamental I. **Material y Método:** Forma de estudio: Estudio de coorte contemporáneo con corte transversal. Fue realizada audiometría tonal liminal en 406 alumnos del primero al cuarto año de una escuela pública de Enseñanza Fundamental I. La evaluación audiológica fue realizada en la escuela con audiómetro MAICO MA41, en cabina acústica. **Resultados:** entre los 406 niños, 50 (12,3%) presentaron alteraciones auditivas en una o ambas orejas, en una o más frecuencias, siendo las peores medias de liminales en la frecuencia de 6000 Hz con alteraciones en un 51,7% de las orejas derechas y 356 niños (87,7%) obtuvieron resultados normales. **Conclusiones:** la evaluación auditiva en escolares, dentro de la propia escuela es válida para la detección de pérdidas auditivas. Por el hecho de que el 12,3% de los niños hayan presentado alteraciones se impone el desarrollo de programas de prevención en salud auditiva. Frente a los resultados encontrados en este estudio, o sea, peores liminales en 6000 Hz, se hace necesaria mayor atención a los hábitos auditivos que los niños vienen desarrollando, cada vez más precocemente.

Palabras clave: Audición; Audiometría de Tonos Puros; Estudiantes; Hábitos..

Introduction

Hearing is an important function for normal language acquisition and development. Thus, if there is hearing loss, some communication problems may interfere with the learning process (literacy and academic performance) and interpersonal relationships (emotional and social development), which in turn can harm development in school. Thus, the identification of hearing problems in schools makes possible the development of actions to promote hearing health and prevent hearing loss^{1,2}.

The Ministry of Health, through the guidelines for the implementation of the Health and Prevention in Schools³, places schools today as a location devoted almost exclusively to caring for children, youth and adolescents, prioritizing preventive actions, individual or collective, that become relevant when they meet social demands. The strengthening and the valuation of practices in the field of hearing health care promotion were assigned to the Brazilian population through an integrated effort between the Ministry of Health and the Ministry of Education.



The systematization of educational, preventive and curative programs for deafness becomes essential because, usually, hearing problems often get overlooked by parents and teachers. With the implementation of these programs, we can mitigate and/ or prevent possible auditory sequelae that can compromise educational performance^{4,5,6}.

In 1998, a study⁷ found that although the prevalence of hearing loss in schools nearly doubles when children with minimal hearing loss are included in the data, there are significant associations between this degree of loss and school performance, and these children experience more difficulty than children with normal hearing.

Several studies^{4,8,9,10,11} have shown a close relationship between language and/ or educational problems and conductive hearing loss type, usually mild to moderate that can produce a feeling of muffled sounds and therefore poor academic performance. However, sensorineural hearing loss is also reported.

A study⁴ conducted with 101 schoolchildren of 7-9 years of age in a public school in São Luis, Maranhão found 75.5% of the ears to have hearing within normal limits, 15% had conductive hearing impairment, 6% had sensorineural alterations, and 2.5% had alterations of a mixed type.

Another study⁹ in Goiania, using pure tone audiometry and impedance, measured the hearing of 121 students from 1st to 8th grade, aged 7-14 years. In this study, 76% (184) ears had normal hearing and 24% (58) ears had hearing alterations. Of these, 12% (26) had conductive hearing loss and 7% (15) mild sensorineural loss.

In a study¹² performed with 86 students from pre-school up to the 4th grade at a private school in the city of Salvador, 94.73% showed normal results in audiometry and 5.23% had conductive alterations. The highest rates of alterations occurred among children from 4 to 6 years old.

The Center of Education and Health Studies in the city of Marília, São Paulo conducted a study¹³ of 150 children, 5-10 years of age, and the results showed normal hearing in 93 children, bilateral hearing loss in 36, and unilateral hearing loss in 21 children. Regarding the type of loss, 48 were conductive, 7 were sensorineural, and 2 were mixed.

The Ministry of Health in Paraná, in a preventive way, developed State Law No. 14023 - 03/02/2003¹⁴, the content of which authorizes the Executive Branch to provide for eyesight and

hearing tests to all students in the state's public school network. Once the determinants and constraints of visual disorders and/ or hearing are identified, measures would be determined and adopted by the Unified Health System (SUS). The Secretary of Health for the city of Curitiba also has drafted a law, No. 11.393/2005-P¹⁵, which provides for the mandatory performance of periodic audiological tests in health centers, day care centers, and school facilities in the city.

Studies in international and national literature^{16,17} since the 70s and 80s discuss the issue of students' hearing. Some studies^{8,10} used the methodology of carrying out hearing screening tests, while others^{4,9,12,13} use research methodology of minimum audibility thresholds. This demonstrates the concern about the impact of hearing loss on school learning and shows that, regardless of the methodology used in research, concern for the hearing health of students constitutes an important and current topic.

Even with enormous technological advances, pure tone audiometry is the basis of audiological assessment that aims to effectively identify the hearing impaired, leading to rapid interpretation and easy application¹⁸.

Based on data from the Ministry of Health in Paraná and the Secretary of Education in the city of Curitiba, audiometry can be an important tool in the early diagnosis and prevention of hearing loss.

In addition to hearing loss resulting from ear infections (conductive hearing loss), exposure to loud noise can also cause sequelae in hearing. Currently, the intensity of existing noise within schools is surprisingly very high, whether from external noise or internal noise from the voices of several adults and children talking at the same time¹⁹.

In addition to this high noise level to which children are exposed in the school environment, there is also exposure to different electronically amplified music sources, whether at home, in the car, or through portable electronics, which are becoming more common among children and adolescents²⁰. These intense levels of noise or music can exceed tolerable hearing limits²¹, endangering the hearing health of these individuals.

The objective of this study was to evaluate the hearing of children from a public elementary school, from November to December 2010, to identify possible changes that allow guidance in preventive and early intervention actions.

Materials

This is a cross-sectional study with students from a public elementary school in the city of Curitiba, Parana.

This study was approved by the Paraná Clinical Hospital Ethics Committee, under CAAE number 0214.0.208.000-11. Parents of children involved signed a consent form for participation in the study.

The school has 581 students from first to fourth grade. Exclusion criteria, adopted were excessive cerumen and the non-delivery of the consent form.

Of the 581 students, 42 (7.22%) were excluded from the sample due to the presence of excessive cerumen, having been referred to an ENT for evaluation; 55 students (9.47%) did not deliver the consent form by the assessment day and were also excluded from the sample; 78 students (13.42%) missed class on the assessment day. Therefore, 406 students participated, 191 females (47%) and 215 males (53%). The age of the students ranged from 6 to 12 years, with a mean of 7.86 years of age.

As part of the School Hearing Loss Prevention Program, there was first an inspection of the external auditory canal, using a Welch Alynoscope, and then minimum audibility thresholds were studied using the descending technique by air at

500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz, using a MAICO MA41 audiometer and TDH39P headphones in a soundproof booth, in a silent room, on school grounds. All necessary precautions were taken in the placement of the earmuff headphones so as not to promote the formation of standing waves.

In this study all tested frequencies were analyzed, adopting as normality criteria a maximum threshold of 15dB HL for each frequency so that hearing loss minimums are detected²² and due to the more critical need of the child to hear during their school development, mainly for consonants which have little energy²³.

Statistical analysis was performed using the Student's t-test, ANOVA and Tukey, at a significance level of 5%.

Results

Among the 406 children evaluated, 50 (12.3%) had hearing loss, or auditory thresholds greater than 15 dB HL, in one or both ears, at one or more frequencies; and 356 children (87.7%) had normal results. Among children who had alterations, 29 (58%) were female and 21 (42%) were male (Table 1).

TABLE 1 - distribution of children by age, gender and hearing alterations (N=406)

Age	Gender		Total N=406		Altered		Total n=50	
	F	M	n	%	F	M	n	%
06 years	31	31	62	15,3	5	4	9	18
07 years	56	65	121	29,8	12	4	16	32
08 years	40	58	98	24,1	5	7	12	24
09 years	33	37	70	17,2	4	3	7	14
10 years	25	22	47	11,6	3	3	6	12
11 years	2	2	4	1,0	0	0	0	0
12 years	4	0	4	1,0	0	0	0	0
Total	191(47%)	215(53%)	406	100%	29(58%)	21(42%)	50	100%

In Figures 1 and 2, the average threshold obtained in the evaluation of all children is shown, as well as the minimum and maximum values for each

frequency by ear. Only one girl of 10 years of age had unilateral hearing loss, severe and congenital on the left side, but of unknown cause.

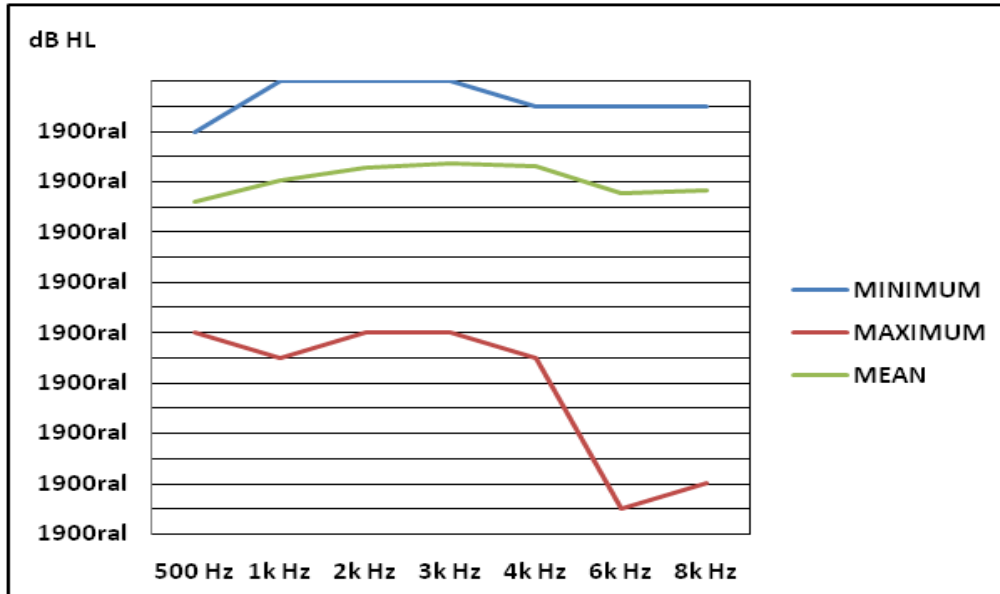


FIGURE 1 – MINIMUM, MAXIMUM, AND MEAN VALUES, OF AIR-CONDUCTED TONAL HEARING THRESHOLDS BY FREQUENCY IN RIGHT EAR OF ALL CHILDREN ASSESSED.

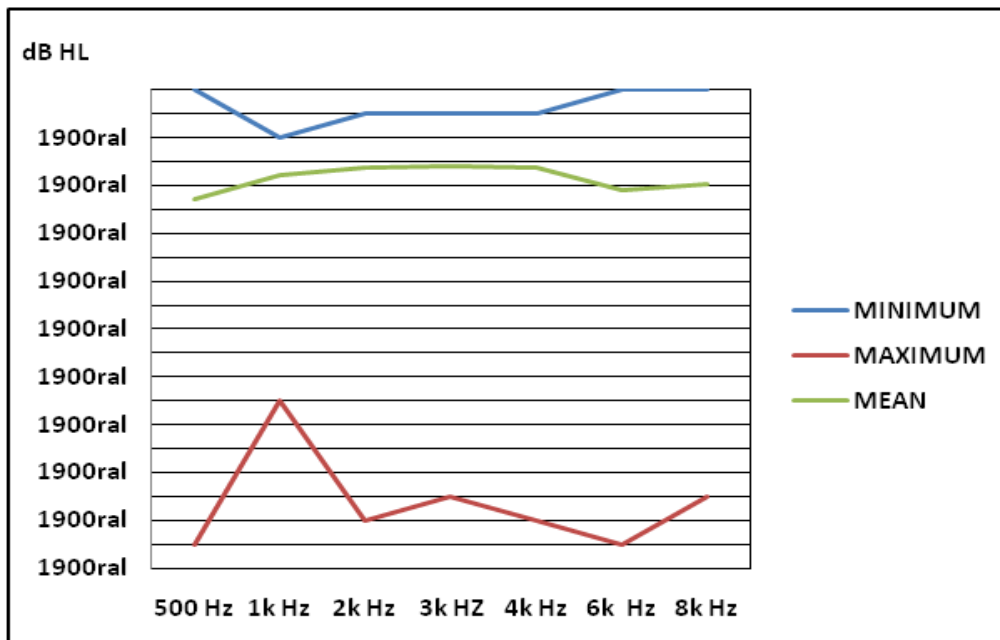


FIGURE 2 – minimum, maximum, and mean values, of air-conducted tonal hearing thresholds by frequency in left ear of all children assessed.

Table 1 shows that 32% of the alterations found occurred in children at 7 years of age, affecting more girls than boys.

Table 2 shows only the results with alterations in air-conducted auditory thresholds in relation to ear, test frequency, and gender. As noted, the greatest number of alterations is at the frequency of 500 Hz, present in 100% of the right ears and 50% of the left ears. This may be due to an effect of masking the environmental noise, although

the evaluations were conducted in a soundproof booth, located in a quiet school room. Next is the frequency of 6000 Hz with alterations in 51.7% of the right ears. Table 3 presents the hearing alterations distributed between the ages 6-10 years. It can be observed that, at the frequency of 6000 Hz, the highest incidence of hearing loss occurred in the right ear of children who were 7 years old and in the left ear for children who were 10 years old.

TABLE 2 - Children With Hearing Distribution Alterations In Relation To Ear, Frequency And Gender (N=50).

Frequency (Hz)	Gender Ear	Male		Female		Total	
		N	%	N	%	N	%
500	Right	24	41,3	34	58,6	58	100*
	Left	11	18,9	18	31,0	29	50,0*
1000	Right	6	10,3	20	34,4	26	44,8
	Left	6	10,3	6	10,3	12	20,6
2000	Right	6	10,3	14	24,1	20	34,4
	Left	3	5,2	8	13,7	11	18,9
3000	Right	5	8,6	10	17,2	15	25,8
	Left	2	3,4	7	12,0	9	15,5
4000	Right	5	8,6	14	24,1	19	32,7
	Left	6	10,3	8	13,7	14	24,1
6000	Right	15	25,8	15	25,8	30	51,7*
	Left	9	15,5	13	22,4	21	36,2
8000	Right	10	17,2	16	27,5	26	44,8
	Left	6	10,3	10	17,2	16	27,5

A Tabela 3 apresenta as alterações auditivas distribuídas entre as idades de 6 a 10 anos. Pode-se observar que, em relação à frequência de 6000 Hz,

a maior ocorrência de alterações auditivas se deu na orelha direita das crianças de 7 anos e na orelha esquerda das crianças de 10 anos.

Table 3 - descriptive statistics of average of air-conducted tonal hearing thresholds in right and left ears of 6 to 10 year olds with hearing alterations (n=50).

Ear and frequency (Hz)	6 year		7 year		8 year		9 year		10 year	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
RE 500	25	7,9	24,7	6,7	22,9	5,4	22,9	7	19,2	5,8
RE 1000	23,3	4,3	21,9	9,8	17,5	6,6	17,1	4,9	13,3	7,5
RE 2000	17,8	6,7	18,8	11,3	16,7	4,9	17,1	3,9	10	5,5
RE 3000	10	5,6	18,8	9,7	15,4	6,6	15,7	5,3	10,8	4,9
RE 4000	10	7,9	19,7	13,2	13,3	7,8	15,7	4,5	10	3,2
RE 6000	20	12	28,1	13,8	18,8	7,4	23,6	22,9	17,5	12,9
RE 8000	15,6	10,7	27,8	12,5	18,8	8,6	23,6	21,5	14,2	9,7

LE 500	19,4	8,1	21,3	8,5	21,7	7,8	20,7	10,6	32,5	26,2
LE 1000	13,3	8,3	19,4	9,8	17,1	9,4	11,4	6,3	24,2	16,6
LE 2000	7,2	5,7	16,6	14,1	15	8	12,1	6,4	25,8	27,5
LE 3000	7,8	5,1	15,9	13,3	15,8	10,6	10,7	4,5	23,3	26,2
LE 4000	7,2	5,7	18,1	16	15	7,1	9,3	6,7	25	27,6
LE 6000	13,9	7,8	24,4	16,9	18,8	10	14,3	6,1	32,5	26,6
LE 8000	13,3	13,5	20,3	14,7	13,3	9,8	14,3	9,8	24,2	25,2

Table 4 presents the statistical analysis of air-conducted auditory thresholds for frequencies among males and females of the 406 children evaluated. At a significance level of 0.05, the Student's t-test observed that there is a significant difference between the mean air-conducted auditory thresholds for males and females at the

frequency of 500 Hz (RE) and 4000 Hz (LE), and girls did worse than boys at 500 Hz (RE) while the reverse happened at 4000 Hz (LE). With respect to frequencies above 2000 Hz, there were worse results at the frequency of 6000 Hz in both ears for both genders, although the statistical analysis did not show significant difference.

Table 4 - comparison of average of air-conducted tonal hearing thresholds, for the and right left ears by frequency and gender (N=406).

Ear	Frequency(Hz)	Male		Female		P
		Mean	SD	Mean	SD	
RE	500	13,1	5,1	14,4	6,5	0,0243*
	1000	9,0	5,4	10,2	7,2	0,0535
	2000	6,4	4,8	7,5	7,2	0,0782
	3000	5,9	5,0	6,4	7,0	0,4398
	4000	6,5	5,1	6,8	7,7	0,6745
	6000	11,1	6,9	12,4	10,2	0,1189
	8000	10,5	6,8	11,9	9,7	0,0808
LE	500	12,3	5,4	13,4	8,2	0,1236
	1000	7,8	5,8	8,0	7,2	0,6772
	2000	6,6	5,4	6,1	8,8	0,4818
	3000	6,1	5,7	5,8	8,6	0,6676
	4000	6,9	6,0	5,4	9,1	0,0431*
	6000	11,4	7,5	10,7	10,3	0,3918
	8000	9,3	6,9	10,0	9,3	0,4206

Student t-Teste with significance level of 0.05; RE = right ear; LE = left ear

Na Tabela 5 são apresentadas as estatísticas descritivas dos grupos segundo as idades, mostrando uma análise das médias dos limiares auditivos tonais aéreos, considerando-se as idades de 6 a 10 anos e as orelhas direita e esquerda. As idades de 11 e 12 anos não foram aqui analisadas pelo número reduzido de crianças (4 crianças com

11 anos e 4 com 12 anos). Pode-se observar que os valores médios dos limiares tonais na frequência de 6000Hz, para ambas as orelhas, apresentaram os piores limiares, principalmente na orelha esquerda das crianças de 10 anos. Este quadro só não ocorreu no grupo de crianças com 6 anos de idade.

Table 5 - descriptive statistics of average of air-conducted tonal hearing thresholds in right and left ears of children 6 to 10 years of age (N=398*).

Ear and frequency (Hz)	6 years		7 years		8 years		9 years		10 years	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
RE 500	13,0	7,2	14,7	5,9	13,3	6,1	13,6	4,8	13,3	4,3
RE 1000	9,2	7,8	11,1	6,8	9,0	5,9	8,9	5,4	8,9	4,8
RE 2000	6,6	6,6	7,9	7,0	6,6	6,0	6,2	5,1	6,7	4,5
RE 3000	4,8	4,8	7,1	7,1	6,3	5,6	5,1	5,7	6,8	5,5
RE 4000	4,3	5,5	7,8	7,9	7,0	5,7	6,6	5,4	6,5	5,8
RE 6000	8,3	9,1	13,0	9,7	12,0	7,0	12,6	8,9	11,3	7,3
RE 8000	7,7	7,3	12,6	8,9	11,3	7,5	11,6	9,5	11,2	6,4
LE 500	11,3	7,1	13,6	5,6	12,4	5,9	12,1	5,9	14,7	11,5
LE 1000	11,3	7,1	9,3	6,7	7,3	6,3	6,4	4,6	9,9	8,5
OE 2000	4,4	4,5	7,3	7,5	6,3	6,0	5,4	5,6	8,5	12,1
LE 3000	4,4	4,8	7,3	7,5	6,3	7,2	4,1	5,2	7,6	11,5
LE 4000	4,0	4,6	7,6	8,4	6,6	6,3	4,8	5,5	7,4	12,3
LE 6000	7,7	7,9	12,0	9,4	12,2	8,0	9,4	6,0	13,5	12,7
LE 8000	6,9	8,3	11,2	8,1	9,4	7,1	8,6	6,1	12,0	11,2

RE = right ear; LE = left ear

*The ages of 11 and 12 were not included in the Table due to the small number of children when compared to the group (n=8).

Table 6 shows a comparison between air-conducted auditory thresholds found in children between 6 and 10 years of age. Comparisons between age groups were performed using ANOVA, at the 0.05 significance level. The identification of groups that differ was performed using the Tukey method. It is observed that children under 6 years of age showed statistically significant differences when compared to other ages at various

frequencies, and at a frequency of 6000 Hz, and this occurs with all other ages, except for 9 year olds. 50 children were referred for audiological evaluation, and only 12 (24%) children attended. Of these 12, nine (75%) confirmed the hearing alterations and were referred for evaluation and treatment by an ENT, speech therapy guidance, and/ or individual hearing aid fitting.

Table 6 - descriptive statistics and p-value obtained in comparing tonal hearing thresholds from the ages of 6 to 10

Ear	Frequency(Hz)	Statistic F	p	Differences between groups
RE	500	1,34	0,2536	No difference
	1000	2,29	0,0591	No difference
	2000	1,04	0,3855	No difference
	3000	2,39	0,0506	No difference
	4000	3,18	0,0138*	G6 ≠ G7
	6000	3,31	0,0110*	G6 ≠ G7, G6 ≠ G9
	8000	3,82	0,0046*	G6 ≠ G7, G6 ≠ G9
LE	500	2,28	0,0597	No difference
	1000	4,32	0,0020*	G7 ≠ G9, G9 ≠ G10
	2000	2,98	0,0191*	G6 ≠ G10
	3000	3,03	0,0176*	G6 ≠ G10
	4000	3,22	0,0129*	G6 ≠ G7
	6000	4,49	0,0015*	G6 ≠ G7, G6 ≠ G8, G6 ≠ G10
	8000	4,30	0,0021*	G6 ≠ G7, G6 ≠ G10

ANOVA with significance level of 0.05; RE = right ear; LE = left ear

Discussion

One of the difficulties in this study was to compare its results with the literature. This difficulty was mainly due to the methodology used by each of the authors regarding the criteria for achieving the audiometric tests, as many performed hearing screening and not research in hearing thresholds, as performed in this study. Another fact concerns the adopted normality criteria, ranging from 15dB HL to 25dBHL. Therefore, the discussion will be made only with the studies using research based on the minimum audibility thresholds and adopting 15dB HL as normal.

In this research, the results found in the air-conducted auditory evaluation showed greater alterations at a frequency of 6000 Hz in both ears, for both genders, although the statistical analysis did not show a significant difference. In a more detailed analysis, it can be seen that, except for at the age of six, the worst average of thresholds is at the frequency of 6000 Hz for both ears at other ages showed an audiometric notch, with the worst in the right ear for 7 year olds and in the left ear for 10 year olds. Although not found in the literature data on studies showing alterations at frequencies

above 2000 Hz in children, a study of adolescents²⁴ found, among other alterations, lowering of these frequencies in two teenagers, one at 6000 Hz in the right ear, and the other at 6000 Hz in the right ear and 8000 Hz in both ears. This represents the possibility that hearing habits in adolescents studied by several authors^{25,26,27}, may be related to the audiometric results found in this study.

A study²⁸ conducted in Australia, with 5490 elementary school children found 55 of them with sensorineural hearing loss, 39 children with a slight hearing decrease (16 to 25 dB HL), and 16 with mild hearing loss (26 to 40dB HL). The authors cited among the risk factors as the use of personal stereos. It is observed that not only in developing countries such as Brazil, but also in developed countries like Australia, there are concerns about the indiscriminate use of personal stereos.

The results in Table 5 confirm those found in Table 6, where it is observed that, in relation to pure tone thresholds, children under 6 years of age show statistically significant differences when compared to other ages at various frequencies, and, at the frequency of 6000 Hz, this occurs with all other ages, except for 9 year olds.

This check can also be related to the argument raised previously with harmful hearing habits that will establish over the course of one's life and that, without proper guidance in schools and families, are happening increasingly sooner.

Another study²⁹ also examined auditory symptoms among youths from 14-30 years of age who use personal stereos, and concluded that schools have not contributed to passing on knowledge about the harmful effects of loud music. The authors suggest more active participation by the school as having a primary role in training young people and promoting educational activities about the risks of inadequate exposure to noise and its impact on health.

Based on the results, it was also found in this study that the lowest thresholds at 6000 Hz highlight a necessary focus on listening habits that children are developing increasingly early. Although this study has not cited specific guidelines about this topic, the results presented here are related to the same issues that are being formulated and researched on the listening habits of adolescents, such as the use of personal stereos with headphones at intensity levels that can damage the auditory system.

Conclusions

Among the 406 children evaluated, 50 (12.3%) had unilateral or bilateral hearing loss in one or more frequencies, especially at 500 Hz and 6000 Hz in the right ear, with the most frequent disorders in children 7 years of age. Among the abnormal results, except for 6 year olds, the worst average thresholds occurred at a frequency of 6000 Hz for both ears, with the worst results in the left ear for 10 year olds.

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