Tinnitus in a riverside population exposed to methyl-mercury

Zumbido em uma população ribeirinha exposta ao metilmercúrio

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ABSTRACT

Purpose: To study the association between the prevalence of tinnitus and mercury exposure and measure the influence of tinnitus on the quality of life. **Methods:** We conducted a cross-sectional study of men and women aged above 18 years residing in the Lake Puruzinho region, which is located on the left bank of the Rio Madeira, Humaita city, Amazonas state, Brazil. All subjects underwent anamnesis, otorhinolaryngologic evaluation, and an audiology test. Individuals who experienced tinnitus completed the translated Tinnitus Handicap Inventory (THI). We also examined the levels of total mercury in the hair of these individuals. **Results:** To analyze the results regarding the prevalence of tinnitus, the subjects were divided into two groups according to the presence or absence of tinnitus. Group 1 was composed of subjects with tinnitus and Group 2 was composed of subjects without tinnitus. Consequently, 40% of individuals had scores consistent with mild handicap according to the THI. The analysis of the association between tinnitus and levels of total mercury in hair samples showed that both groups had high levels of mercury. However, this finding was not significantly different between groups. **Conclusion:** Herein, 25% of the subjects complained of tinnitus and significant exposure to mercury; however, there was no association between the prevalence of tinnitus and high levels of mercury.

Keywords: Tinnitus; Mercury; Hearing loss; Public health; Questionnaires

RESUMO

Objetivo: Estudar a prevalência de zumbido, verificando se há associação entre a queixa desse sintoma e o teor de mercúrio e mensurar seu impacto na qualidade de vida. **Métodos:** Estudo seccional em toda a população do Lago do Puruzinho, localizada na margem esquerda do Rio Madeira, cidade de Humaitá, Estado do Amazonas, Brasil. Todos os residentes maiores de 18 anos, de ambos os gêneros, foram submetidos à anamnese, avaliação otorrinolaringológica e exame audiológico. Os indivíduos que apresentaram queixa de zumbido responderam à versão traduzida do questionário *Tinnitus Handicap Inventory* (THI). Também foram pesquisados os teores de mercúrio total no cabelo desses indivíduos. **Resultados:** Para análise dos resultados sobre a queixa de zumbido, os sujeitos foram divididos em dois grupos quanto à presença ou não de zumbido. O Grupo 1 foi composto por indivíduos que apresentaram queixa de zumbido e o Grupo 2, por indivíduos sem zumbido. Foi observado que 40% dos indivíduos apresentaram escores do THI compatíveis com *handicap* leve. A análise da associação da presença de zumbido com os teores de mercúrio total no cabelo mostrou que ambos os grupos apresentaram níveis elevados de mercúrio, porém não ocorreram diferenças entre os grupos. **Conclusão:** Um quarto dos ribeirinhos apresentou queixa de zumbido e exposição significativa ao mercúrio, mas não houve associação entre o zumbido e os níveis elevados de mercúrio.

Descritores: Zumbido; Mercúrio; Perda auditiva; Saúde pública; Questionários

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INTRODUCTION

Gold mining with unregulated use of mercury is associated with considerable risk of environmental contamination and to human health. This is a fundamental issue in the Amazonian region[1]. Mercury constitutes a serious risk for human health because it is highly prone to bioaccumulation and cause a series of noxious health effects[2,3].

Among the populations experiencing the highest impact from environmental mercury contamination are those who eat contaminated fish as part of their basic diet, especially the communities residing by the riverside. For the riverside communities of the Amazonian Basin, such as the population of Lake Puruzinho, the main source of protein is fish[4] (average consumption of 406 g/day[5]), which is the primary vehicle for environmental exposure to methyl mercury.

Methyl mercury can cause cerebral damage and lead to decreased motor coordination associated with altered speech and locomotion, paresthesia, ataxia, neurasthenia, tremors, lack of equilibrium, weakness sensation, fatigue, difficulty with concentration, and diminished vision and hearing capacities, besides other effects such as teratogeny and ultimately death[6].

A systematic review of published studies focused on the effects of mercury on the peripheral and/or central auditory system indicated that mercury is ototoxic and induces peripheral and/or central damage. Hearing loss is a frequent symptom in individuals exposed to mercury, and vestibular syndromes of central and peripheral origin can also occur[7].

Exposure to methyl mercury during gestation can influence the development of the auditory system. The delay in wave III of the auditory evoked potential of the encephalic trunk was established as a biomarker of prenatal exposure through the consumption of contaminated seafood[8]. Another study suggested that persistence of prolonged I–III inter-peak latency indicates that previous intra-uterine exposure to methyl mercury is irreversible, which is suggestive of alterations to the central auditory system at the encephalic trunk[9].

Tinnitus can be caused by the presence of lesions in and/or functional alterations to the neurosensory auditory system, originating either at the internal ear or at the central auditory system. Hearing loss is frequent in patients with tinnitus complaints; however, some patients have no hearing impairments and still complain of tinnitus[10].

Tinnitus can also be associated with other factors, such as emotional, odontological, spinal, or metabolic alterations[11], and affects approximately 17% of the population, with 15% to 25% reporting interference in their quality of life[12].

Because there is no objective method to detect tinnitus or determine its severity, the use of questionnaires for evaluating patients with tinnitus is paramount[13]. These questionnaires aim to assess functional effects and comprise several items that determine the influence of tinnitus on various aspects of daily life[14].

One of these questionnaires is the Tinnitus Handicap Inventory (THI)[15], which also has a Portuguese version[16].

To the best of our knowledge, no study assessed the prevalence of tinnitus in populations exposed to mercury. Therefore, the main objective of this exploratory study was to assess the prevalence of tinnitus in a riverside population with environmental exposure to mercury by determining the total mercury levels in hair samples and measuring the influence of tinnitus on the quality of life.

METHODS

This study adhered to the ethical aspects of Resolution 196/96 established by the National Council of Health for Research (*Conselho Nacional de Saúde sobre Pesquisa*) involving humans, and included, among others, informed terms of consent. The study was approved by the Research Ethics Committee (*Comitê de Ética em Pesquisa*, CEP) of the Institute of Public Health of the Universidade Federal do Rio de Janeiro (UFRJ) (approval number 79/2011).

This sectional study was performed in March 2012 to evaluate the prevalence of tinnitus in men and women older than 18 years residing at Lake Puruzinho, which is located on the left bank of the river Madeira, Humaita city, Amazonas state, Brazil.

This population lives off subsistence agriculture and is continually exposed to methyl mercury because its dietary animal protein source is fish, and to a lesser extent, mammals and birds. This location was established as a laboratory for environmental studies and considered a model system of a riverside community of the Madeira river basin[4].

The entire study was performed with 41 individuals, 20 men and 21 women aged between 18 and 68 years. The aim of the research was to assess the entire community, independently of sex and age. The exclusion criteria were not being able to undergo a conventional audiometry or the presence of conductive or mixed hearing loss[17], as this type of hearing loss correlates with conditions of the outer and middle ear; mercury exposure is associated with sensorineural hearing loss[18].

During anamnesis, patients were asked to provide information on personal data; general health condition; professional activity; education; diet; time spent living in the community; history of diseases such as hypertension and diabetes; smoking habits; alcohol dependence; compulsion for sweets, coffee, and chocolate consumption; current medication use; among other factors possibly related to tinnitus. The existence of altered temporomandibular joints, along with a history of otologic surgery, hearing diseases, hearing loss, presence or absence of tinnitus, and family history of hearing problems were also determined.

Individuals reporting tinnitus were asked to complete the translated version of the Tinnitus Handicap Inventory (THI)[16], which is composed of 25 questions with the possible answers of "yes" (4 points), "sometimes" (2 points), and "no" (no points)[19]. In the end, the sum yields a score from 0 to 100 and the higher

the score the bigger is the repercussion of the tinnitus on the quality of life of the patient. Tinnitus handicap can be classified as "vestigial" (0 to 16 points), "mild" (18 to 36), "moderate" (38 to 56), "severe" (58 to 76) or "catastrophic" (78 to 100). The questionnaire session was conducted by only 1 interviewer while the content was read to the interviewed person.

Otoscopy was performed to evaluate any alterations at the level of the external auditory meatus, such as the cerumen, that could compromise the hearing test.

The hearing test consisted of tone audiometry using an audiometer (AC-33 Interacoustics®, Denmark), with a frequency ranging between 500 Hz and 8000 Hz[20,21]. Hearing was considered normal if it was ≥15 dBNA at a frequency range of 500 Hz to 8000 Hz on the audiogram[20,21].

The acoustic immittance tests were performed with an automatic middle ear analyzer (AT235 Interacoustics®, Denmark); type A tympanometry and contralateral and bilateral acoustic reflexes detected in the range of frequencies 500 Hz to 4000 Hz were considered normal[22].

Blood tests were performed to determine the levels of total cholesterol and its fractions, as well as the levels of thyroid-stimulating hormone and free thyroxin. Arterial and diastolic blood pressure was measured to explore the presence of other diseases potentially associated with tinnitus.

Total mercury levels, due to exposure to methyl mercury, were quantified in hair samples from 22 subjects using cold vapor atomic absorption spectroscopy (Flow Injection Mercury System, FIMS-400 from Perkin Elmer®); the analyses were conducted by the Wolfgang C. Pfeiffer Laboratory of Environmental Biogeochemistry of the Federal University of Rondonia.

All data were collected during the same week. Because this was a prevalence study, the SPSS program version 14.0 was used for statistical analyses.

RESULTS

Subjects were divided into two groups according to the presence or absence of tinnitus. Group 1 was composed of ten subjects who complained of tinnitus and Group 2 was composed of 31 subjects without tinnitus. This study showed that 25% of the individuals from the Puruzinho community who were tested had tinnitus.

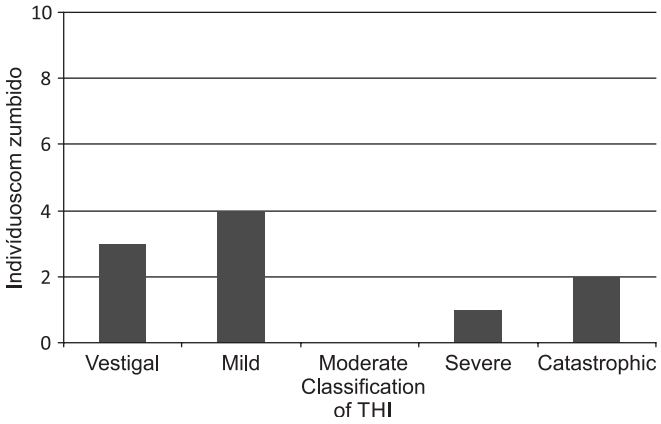
The analysis of the association between tinnitus and levels of total mercury in the hair samples showed that both groups had mercury levels that were higher than the reference level established by the World Health Organization (6.0 $\mu g \cdot g^{-1}$)[23]; however, there were no statistically significant differences between groups (Table 1).

In Group 1, the THI scores varied from 4 to 84, with an average of 36.8. Mild handicap was noted in 4 (40%) subjects; vestigial handicap, in 3 (30%) subjects; catastrophic handicap, in 2 (20%) subjects; and severe handicap, in 1 (10%) subject. There were no cases of moderate handicap (Figure 1).

Table 1. Levels of total mercury in hair samples from the Puruzinho riverside community

Mercury in hair	Individuals with tinnitus (n=10)	Individuals without tinnitus (n=31)
Total mercury in hair ($\mu g.g^{-1}$)	13.5 ± 8.5	12.1 ± 6.3
n	4	18
Median	16.0	12.2
Mínimum	8.0	3.7
Máximum	23.4	23.2

Differences between subjects with and without tinnitus according to total mercury levels in the hair ($\mu g.g^{-1}$)



Note: THI = Tinnitus Handicap Inventory

Figure 1. Distribution of THI results in subjects with tinnitus

Attempts to correlate tinnitus with hearing loss showed that subjects with tinnitus had a higher incidence of altered audiometry test results (20%), with hearing loss at high frequencies (6000 and 8000 Hz) (Table 2).

Table 2. Distribution of the presence or absence of tinnitus according to audiometry results

Audiometry	Tinnitus			
	Present		Absent	
	n	%	n	%
Normal	8	80.00	27	87.10
Amended	2	20.00	4	12.90
Total	10	100.00	31	100.00

There were no differences between groups in terms of variables that could lead to confounding, such as high caffeine consumption, hypertension, diabetes, alcohol consumption, smoking habit, temporomandibular dysfunction, ototoxic medication use, cervical vertebrae problems, head injury, and otologic alterations.

Laboratory exams showed that the levels of thyroid-stimulating hormone and free thyroxin were normal. Levels

of total cholesterol and its fractions were within the reference range, which indicated that these variables are not associated with tinnitus (p values not significant).

DISCUSSION

Tinnitus is a prevalent condition that affects millions of people worldwide but remains poorly understood among health professionals[24].

Tinnitus can cause impairments in thought, memory, and concentration. These alterations can harm leisure activities, rest, communication, and social and domestic environments, thus interfering with aspects of the psyche and causing irritation, anxiety, depression, and insomnia, which directly affect the quality of life[12].

Because any clinical situation altering the physiology of the auditory system can be associated with tinnitus, several possible confounding variables were studied through the questionnaire and laboratory examinations. Nonetheless, no correlations were found between any of these variables and the presence or absence of tinnitus. A study did, however, indicate that alterations in the auditory system caused by noise-induced hearing loss, acoustic trauma, presbycusis, and ototoxicity could be associated with tinnitus[10]. The fact that there were no differences between individuals with and without tinnitus in terms of the assessed variables is possibly meaningful, because patients with tinnitus should also be evaluated for metabolic, cardiovascular, neurological, pharmacological, odontological, and psychological changes[12].

Our study showed that 25% of subjects had tinnitus, with a mild influence on the quality of life. The correlation between hearing loss measured by audiometry and the level of handicap that tinnitus causes is associated with the way the patient copes with the tinnitus and not with any physical or anatomical variable[25].

The inclusion of robust psychometric evaluations to assess the restriction of activity and the limitation/participation in clinical protocols will continue to be highly valuable in clinical practice for audiology, otology, and otoneurology[26].

The levels of total mercury in the hair samples determined in the Lago Puruzinho community were similar to that reported in other studies of riverside communities of the Madeira river basin, which had higher levels of mercury exposure[27].

Occupational exposure to mercury is undeniably harmful. However, the effects on public health are still poorly explored; usually, the toxicity of chemical pollutants occurs chronically, with no classical clinical scenario associated with any of the substances[28].

Previous studies have described auditory limits within the normal standards. Nonetheless, an altered auditory evoked potential, with increased latency between wave peaks III and V[9], as well as the implication of central auditory processing, with lower-than-expected results[29], indicate that mercury has a greater neurotoxic effect on the central nervous system than the peripheral level.

To the best of our knowledge, this study is the first to exclusively assess the prevalence of tinnitus associated with mercury exposure; any other possible causative effects were excluded.

Knowing that chronic exposure to mercury can have ototoxic and neurotoxic effects, and taking into consideration the high prevalence of tinnitus in this population, a complex approach should be undertaken from the public health perspective to promote actions preventing environmental contamination. Because this is a sectional study, the entire population was analyzed at a particular period of time; therefore, the time of data collection and the results did cannot be used to confirm an association with tinnitus.

The high levels of mercury in the hair samples detected in this study can be established as a potential model for clinical and subclinical monitoring studies. Importantly, this was a preliminary and exploratory study, which can serve as a reference for the analyses of other populations exposed to methyl mercury, as well as in studies of medium- and long-term tinnitus associated with toxicity.

This study has limitations such as the small sample size, presence of diseases potentially associated with tinnitus, and the difficulty to establish a control group with no mercury exposure in a riverside population.

CONCLUSION

The community residing at Lake Puruzinho showed a high prevalence of tinnitus. However, no association could be observed between tinnitus and the levels of mercury detected. When considering the influence of tinnitus on the quality of life, most individuals demonstrated mild handicap.

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