Children Have as Much Tinnitus as the Elderly

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Case report

A 6-year-old boy presented to a first appointment with his mother in March, 2010.

Present history: One month previous, he had noticed a ringing tone in both ears while he was lying down in bed before sleeping. He had the habit of falling asleep in the parents´ bed, and his father used to have a fan turned on in the bedroom. The child first perceived his tinnitus when the father had traveled, and the mother didn´t turn the fan on before he fell asleep. In following nights he realized that the noise of his father´s fan used to quickly mask the sound of his tinnitus.

From the medical point of view, the boy was very consistent in answering questions. The visual analogue scale for annoyance with tinnitus (from 0 to 10) was rated as a 5. He had no other complaints such as hearing loss, hypersensitivity to sounds, aural fullness, recent trauma by or exposure to noise, nor use of medicines. His mother complained that he was not eating very well at that time.

Past history: he had had five episodes of otalgia about three years before, which improved after starting a routine of nasal cleaning with saline solution. Because the mother used to seek help from homeopathy and phytotherapy rather than from a medical clinic, she was not sure whether these episodes were otitis.

Positive familial history: father and grandmother have a clinical diagnosis of otosclerosis.

Physical examination was normal, except for a mild retraction of tympanic membranes and hypertrophy of both tonsils (++/4).

Audiometry and imittanciometry: normal thresholds from 250 to 8,000 Hz (up to 15 dB HL) in both ears, SRT: 100% and 100%, Curve A, normal acoustic reflexes

Tinnitus matching: 6,000 Hz, 10 dB SL (right ear) and 18 dB SL (left ear).

Mother and son were counseled about what tinnitus is and why it is reinforced during silence. No drug therapy was tried because the annoyance was intermittent and there were contraindications in family habits and concerns. Conversely, a treatment based on desensitization to sounds during the night was recommended. After two months (May, 2010), the mother was contacted by phone call. She said that the child was regularly sleeping using low-level sounds of nature for

the whole night, and that he had not made any reference to tinnitus since then. She was afraid to keep asking her son how his tinnitus was, lest she increase his awareness by doing so. She was advised to keep following up in monitoring his tinnitus and hearing, especially because of his familial history of hearing loss.

Tinnitus does exist in childhood. This simple case is presented to motivate professionals to pay attention to a commonly under-recognized symptom and to show how trustworthy children can be, even regarding subjective symptoms such as tinnitus. A first step in improving clinical practice is to include a single question in the routine anamnesis about the ear, such as "Do you hear a noise inside your ears?" If so, "What does it sound like?" and "Does it bother you?"

Introduction

Tinnitus is considered to be a phantom sound, that is a sensation of sound which cannot be attributed to an external source of sound. It is a common symptom in the general population (15%, according to the National Institutes of Health in 1996), especially in the elderly (33%). It can be compared to headache and dizziness, which can be caused by many different etiologic factors but cannot always be clarified even after detailed investigation. Regardless of the generating source, tinnitus is perceived in the auditory cortex.[1] In most cases it reflects a hyperactive state of the auditory pathway, as a result of sensory overstimulation or deprivation.[2] Thus, increased spontaneous activity [3] and reorganization of the auditory cortex following decrease of peripheral input are the main mechanisms to explain the physiopathology of tinnitus.[4,5]

Tinnitus may affect individuals in an intense and even dramatic way, interfering with sleep, concentration, and social life. As a result, emotional problems such as anxiety and depression and resultant behaviors are often seen.[6]

Children are not small adults. Their auditory pathways and connections are undergoing a process of maturation,[7] so their system can be expected to be more plastic than that in adults. If this is true, it would be more likely to be influenced by external or internal agents.[8] Although children experience tinnitus as often as adults, they usually react differently,[9] rarely seeming to be bothered.[10]

Investigating tinnitus in childhood is challenging because of its subjectivity and some peculiarities among children. Mills and colleagues[11] suggested that statistics regarding children are underestimated due to communication skills. Conversely, Stouffer and coworkers[12] argued that children have a tendency to over-report tinnitus when asked, in order to please the investigator. So, it is important to keep in mind that rates obtained in clinical appointments do not reveal the true prevalence of tinnitus in children, because they rarely refer to it spontaneously[13,14] and the pediatric ENT evaluation seldom routinely explores for it.

Population studies on the epidemiology of tinnitus among children have disclosed rates of prevalence as discrepant as 6% to 53% (**Table 1**). These studies have differed significantly in their methods of collecting data, diagnostic criteria, and age-groups.

Table 1. Epidemiological studies on tinnitus among children in general population.

Authors	N	Age	Diagnosis by the question	Prevalence	
Nodar (1972)	2000	10-18	"Do you hear a noise in your ears like ringing, buzzing or a click?"	13.3% in normal hearing	
Mills et al (1986)	93	5-16	No exact definition	29% perception of tinnitus	9.6% annoyance with tinnitus
Stouffer et al. (1991)	161	7-12	"Do you hear a noise in your head for more than 5 minutes?"	13% in normal hearing 6% after consistency criteria	29% in hearing-impaired patients 24% after consistency criteria
Holgers (2003)	964	7	(a)"After listening to loud music or loud sounds/noise, have you afterwards heard a ringing, buzzing or other sort of noise in your ears, even if the loud music or noise has been turned off?" (b) "Have you heard a ringing in the ears, without first having listened to loud music or other loud sounds?"	13% in patients with normal hearing	8.8% in hearing-impaired patients
Holgers, Petterson (2005)	671	13-16	(a)How often do you experience tinnitus", (b) "How often is tinnitus annoying" (c) "Thoughts about tinnitus"	53% tinnitus perception	27% tinnitus annoyance
Coelho, Sanchez, Tyler (2007)	506	5-12	Perception of tinnitus: "Do you hear a noise inside your ears/head?" If there is a positive answer: "Where do you hear it?" + "What does it sound like?" Suffering from tinnitus: perception of tinnitus + positive answer to "Does it bother or annoy you?" and "In what situations does it bother or annoy you?"	37.5% perception of tinnitus	19.6% annoyance with tinnitus

An important aspect of the investigation is differentiating between the perception of a sound (sensation of tinnitus) and the impact that it causes on a child (suffering from tinnitus). This allows for more detailed information and provides for a measure of the prevalence of problematic tinnitus; unfortunately, this differentiation has rarely been adopted in pediatric studies that have been published to date, as seen in the table above. So, I will detailed some aspects of our epidemiological research, which was published in 2007 (Coelho CB, Sanchez TG, Tyler RS. Tinnitus in children and associated risk factors. Prog Brain Res. 2007;166:179-91)[15]

Main topics of the methodology

Aiming to establish the prevalence of tinnitus in a general pediatric population and establish risk factors for the onset of tinnitus, we performed a prospective cross-sectional study among 13,000 children in public and private elementary schools. Among them, 700 were randomly selected, and the final sample included 506 children between five and 12 years old. After a well-designed two-stage cluster sampling (see more details in Reference[15]) in 44 public and private Brazilian schools, the directors of the selected schools distributed to the parents an explanatory letter, a questionnaire to be filled out at home, and the letter on informed consent. One week later, the teachers collected the returned letters.

Procedures

Data from the questionnaires were collected from parents (after written consent), and interviews were conducted with the children (after verbal consent), followed by otoscopic evaluation and hearing tests. All children were interviewed and examined by the same professionals. All children underwent otoscopy, removal of wax and debris (whenever needed), air-conduction audiometry, tympanometry, and testing of the contralateral acoustic reflex threshold in a portable acoustic cabin. Some criteria were adopted to increase the reliability of the children's answers, so as not to overestimate the symptoms. Data were classified as:

(1) Sensation of tinnitus: positive answer to the question "Do you hear a noise inside your ears/head?" If a positive answer was given, children had to be able to describe "Where do you hear it?" and "What does it sound like?"

(2) Suffering from tinnitus: classified as having a sensation of tinnitus and positive answer to the question "Does it bother or annoy you?" If a positive answer was given, they were asked to describe "In what situations does it bother or annoy you?"

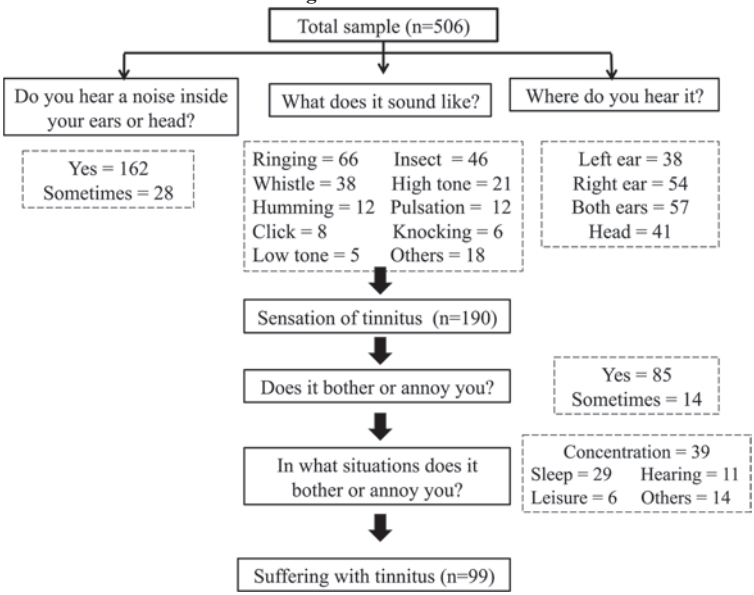
Statistical analysis

A chi-square statistical or two-sided Fisher's exact test was used to access bivariate associations of risk factors and demographics, as well as symptoms. Unconditional logistic regression was used to examine multiple independent variables for their association with the outcomes. Final multivariate models were designed using a saturated model and manual backwards elimination. Covariates with bivariate P-values <0.1 were considered for inclusion in all logistic regression models, while multicolinearity was checked. Logit plots (estimated log odds) with continuous variables were used to check linearity. Lastly, intervals of 95% confidence were computed around adjusted odds-ratios.

Results

The final sample was composed of 506 children, divided in 266 boys (52.6%) and 240 girls (47.4%), of which 86.2% were white (**Figure 1**). Their mean age was 9.46 years (SD = 2.09 years). Hearing thresholds were normal in 81%, minimal to mild loss in 14%, and moderate to profound loss in 4% of the children. A sensation of tinnitus occurred in 37.5% of the children (n =190) and suffering from tinnitus in 19.6% (n = 99) (**Figure 1**).

Figure 1. Final results



Risk factors for sensation of tinnitus and suffering from tinnitus were: mild hearing loss, age, female gender, history of exposure to noise, motion sickness, and intolerance for some sounds. Risk factors for sensation of tinnitus / suffering from tinnitus (multivariate regression model) (**Table 2**).

Table 2. Risk factors for sensation of tinnitus and suffering from tinnitus

Variable	Sensation of tinnitus OR (95% CI)	Suffering from tinnitus OR (95% CI)
Age (continuum)	1.1 (1.06-1.3)	1.2 (1.1-1.4)
Gender (male *vs.* female)	---	0.5 (0.3-0.9)
Hearing Loss		
Normal hearing	Reference value	Reference value
Minimal to mild loss	1.8 (1.05-3)	2.4 (1.4-4.4)
Moderate to profound loss	0.5 (0.2-1.6)	1.1 (0.3-4.1)
History of exposure to noise (positive x negative)	1.8 (1.1-2.9)	2.8 (1.6-4.8)
Motion Sickness (positive x negative)	1.8 (1.3-2.7)	---
Intolerance for sounds (positive x negative)	---	4.2 (1.4-12.6)

Important topics to have in mind

Prevalence of tinnitus

Rigorous criteria were adopted to classify tinnitus in our study, in order to attenuate inherent problems that might come up when dealing with a pediatric population. Our finding of prevalence in childhood was very high, similar to the expected one in the elderly. However, such prevalence was intermediary between those of two studies that had used the same criteria for classification (Mills et al, 1986 and Holgers and Petterson, 2005).

Prevalence of tinnitus according to audiometric thresholds

In children with normal audiometric thresholds, a sensation of tinnitus occurred in 37.7% (n = 150) and suffering from tinnitus occurred in 17.8% (n = 70). Prevalences described in other studies were lower, varying from 6%[12] to 13%.[16, 17] In our study, a sensation of tinnitus occurred in 50% of the children (n = 34) with mild hearing loss and in 23.5% (n = 4) who had moderate to profound hearing loss. Suffering from tinnitus was present in 33.8% of the children (n = 24) with minimum to mild hearing loss and in 18.8% (n = 3) of those with moderate to profound hearing loss. Our findings are similar to those previously reported for hard-of-hearing children, where the slighter the degree of hearing loss, the higher the prevalence of tinnitus.[18,19] Such diverse prevalence among these studies could be a result of (a) definition of tinnitus, which differs from author to author; (b) variance in age of children studied, from five to 18 years, (c) methodology and classification of audiometric results; (d) cultural aspects.

Tinnitus as a spontaneous complaint

Only eight children (1.6%) described tinnitus spontaneously, reinforcing the finding that children rarely complain of tinnitus [13,14]. Many hypotheses have been raised to explain this dissociation among children: (a) they rarely refer to symptoms that are not associated with pain[14]; (b) they have a less developed body image[20]; (c) they perceive tinnitus as a familiar experience[21]; (d) they are easily distracted by external environments[22]; (e) they do not perceive the medical significance of the symptom.[23] Because children will rarely mention tinnitus, the only way to investigate the symptom and possible effects on life is to ask them directly. However, care must be taken in such an approach, since children tend to give positive answers to please the interviewer.[12] It is equally important to minimize possible concerns after being diagnosed with tinnitus by a fully comprehensive investigation and counseling.

Interference of tinnitus in everyday life

There are no instruments developed to investigate annoyance among children, for example no questionnaire or visual-analog scales that have been validated to study tinnitus in the pediatric population. Difficulty in concentration (33%), sleeping (24%) and hearing (9%) were the most frequent complaints.[15] They also related interference in leisure and sports and the symptom was associated with headache and dizziness. Similar findings among children are described by Martin and Snashall[9] and by Gabriels.[24] Decrease in performance at school was related by Drukier[25] and by Kentish and colleagues.[26] Performance at school was not objectively tested, but if a child presents with problems in concentration,

he or she is prone to have difficulties in school. All these findings are similar to those related by adults who seek treatment for tinnitus in Brazil.[15] Tinnitus can be distressing in children as it is in adults.

Prevalence of tinnitus: adults compared with children

In a historical experiment on the sensation of tinnitus, Heller and Bergman[27] reported that 94% of subjects who entered a soundproofed booth reported some form of tinnitus. Using more detailed methodology, Knobel and Sanchez found that 70% of asymptomatic young adults were able to perceive sounds of tinnitus after staying for five minutes in a silent chamber.[28] Most epidemiological studies base their definition of tinnitus on an experience perceived for more than five minutes. Rates of prevalence of tinnitus vary from 25% to 44%,[29] 29%,[30] 14.2%,[31] and 10%.[32] Besides differences in methodology and definition, the discrepant prevalence found in this pediatric population when compared to adults might also reflect differences in behavior and maturation of the auditory pathway.

Risk factors associated with a sensation of tinnitus and suffering from tinnitus

Age

The risk for a sensation of tinnitus and for suffering from tinnitus has been shown to be progressive as age increases, with a risk of 1.1 and 1.2 times respectively for every year age is raised. Among young adults (18 to 24 years of age), Hinchcliffe[30] and Leske[29] described prevalence of tinnitus in 21% and 26.6 % respectively, and it declined after 65 years of age. Also among adults, this fact is clearly demonstrated by Hoffman and Reed,[33] who described a progressive prevalence of tinnitus proportional to age, declining after a plateau around 65 years of age.

In children, the progressive risk for tinnitus associated with age could be related to an increase in cognitive capacity or to cumulative exposure to many factors implicated in the etiology of tinnitus such as exposure to noise.

Gender

Most epidemiological studies among adults show similarity of prevalence between genders or show a small increase in women when compared to men. In our study, girls had an odds ratio of 0.5 (95% IC, 0.3 - 0.9) for presentation of suffering from tinnitus when compared to boys. Possible explanations for this fact may include: (a) girls present a higher tendency to express symptoms than boys, including those related to affective disorders; [34] (b) spontaneous otoacoustic emissions, which have been described as a possible etiologic factor for tinnitus,[35] are more frequent among females,[36] and (c) genetic differences between genders are associated with expression of neurotransmitters pursuing action on auditory pathways, including serotonin.[37]

Hearing loss

The prevalence of tinnitus in children with hearing loss has been shown to be greater than that in normally hearing children. Among children with moderate to profound SNHL, tinnitus is less prevalent than in those children with minimum to mild hearing loss. So, minimum to mild hearing loss is a risk factor for tinnitus, having an odds ratio of 1.8 for a sensation of tinnitus and 2.4 for suffering from tinnitus.

Exposure to noise

History of exposure to noise was a risk factor for both the sensation of tinnitus and suffering from tinnitus, presenting an odds ratio of 1.8 (IC 95% 1.1 - 2.9) and 2.8 (IC 95% 1.6 - 4.8), respectively. A similar finding among children has been described by Holgers and Petterson.[38] In our sample, the most frequent situation involving exposure to noise was related to firecrackers that might reach peak levels of 145 to 165 dB HL at two meters or less from the site of the explosion.

Norena and Eggermont[39] have demonstrated that even a mild hearing loss after acoustic trauma could promote tonotopic reorganization of the auditory cortex.[40,41] Cortical neurons with characteristic frequencies in the region of the hearing loss were found to: (a) respond to the frequency tuning of their less-affected neighbors, (b) show an increased spontaneous activity, and (c) present an increased neural synchrony.[42,43] A potential link between exposure to excessive noise, reorganization of the cortical tonotopic map, changes in spontaneous firing rates of neurons, and tinnitus has been suggested by Eggermont and Roberts.[44] An elegant paper recently published by Noreña and coworkers[45] demonstrated that acoustic stimulation initiated immediately after exposure to noise prevents tonotopic changes in the primary auditory cortex in animals.

All these findings strengthen the need for educational and informational programs about tinnitus in childhood, as well as about exposure to noise among school-aged children, not only considering the risk for hearing loss but also because it is a crucial feature in prevention of tinnitus. Once trauma from noise is established, an early diagnosis followed by prompt treatment might prevent serious consequences such as suffering from tinnitus.

Hyperacusis

Complaints of intolerance of sounds have been described in 30% of children presenting tinnitus.[36] Hyperacusis has been suggested to be a precursor for development of tinnitus,[46] becoming worse as long as tinnitus develops. On the other hand, it has also been suggested that tinnitus may precede hyperacusis[47,48] with an increase in prevalence as tinnitus evolves. In our study, the presence of hyperacusis was demonstrated to be the highest risk factor for suffering from tinnitus, with an odds ratio of 4.2 (CI 95% 1.4 -12.6). It is evident that children with an altered perception of external sounds, as occurs in hyperacusis, might also be annoyed by an "internal sound." Both symptoms might share a common pathophysiological substrate, but it does not mean that the occurrence of hyperacusis *per se* is a precondition to developing tinnitus or vice-versa.

Conclusion

A sensation of tinnitus is a common finding among children, affecting as many as 37% of them. In 19%, it may cause suffering due to interference with concentration, sleeping, and social interaction, becoming a problematic symptom. Thus, the prevalence of tinnitus in childhood is similar to that in the elderly, deserving more attention from the professionals involved in taking care of them.

Despite this large incidence, tinnitus in children is still an unrecognized problem, particularly in children with normal hearing. Indeed, about half of children with tinnitus have normal hearing thresholds.

Because children seldom complain spontaneously, tinnitus is likely to be unnoticed by parents, teachers, and physicians. However, children are sometimes surprisingly detailed in describing their sensation of tinnitus and the interference that it causes in their daily routines. Thus a medical protocol for identifying and analyzing tinnitus is of interest, so as to minimize its damage in the pediatric population. Moreover, awareness about tinnitus as a common problem and about its prevention should be raised in schools and in those participating in high-risk activities, to help avoid exposure to noise, limit the time of exposure, and/or use protection for hearing, to help avoid tinnitus and hearing loss.

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