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HYPERACUSIS AND ASSOCIATED FACTORS IN SCHOOLCHILDREN: AN INTERNET SURVEY BASED ON REPORTS FROM BOTH PARENTS AND CHILDREN

Contributions:
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B Data collection/entry
C Data analysis/statistics
D Data interpretation
E Preparation of manuscript
F Literature analysis/search
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Abstract

Introduction: The aim was to investigate sound tolerance in schoolchildren aged 9–14 years, examine differences across age groups, and identify possible associated factors.

Material and methods: This was a cross-sectional exploratory study. An internet-based survey was conducted with children aged 9 to 14 years and their parents/guardians, recruited via social media. Parents/guardians and children completed separate questionnaires; the one developed for children has not been formally validated although it has been applied in prior pediatric studies. Hyperacusis was classified as present when both parent and child report were positive. Associated factors were analyzed using Fisher's exact test to compare individuals with auditory hypersensitivity in terms of whether they were also sensitive to lights, odors, or motion sickness. Inter-rater agreement between parents and children was evaluated with the kappa coefficient (κ).

Results: From the 75 parents recruited, there were just 60 questionnaires that had been completed by their children (age range 9–14 years; mean 12 years; 61.7% male). Listening difficulties were more frequently reported in children aged 9–10 years ($p = 0.010$), while earphone use was significantly higher among adolescents aged 13–14 years ($p = 0.010$). Motion sickness was more prevalent in children aged 11–12 years ($p = 0.033$). Tinnitus was reported by 20% of children, and hyperacusis by 10.3%, with no significant differences across age groups. Sensitivity to light and odors was significantly associated with hyperacusis according to parents' reports ($p = 0.007$) and to children's reports ($p = 0.020$). No association was observed between motion sickness and hyperacusis.

Conclusions: Although the prevalence of hyperacusis among schoolchildren was relatively low, the occurrence of sound-related discomfort was notable. Sound tolerance should be considered in clinical evaluations. The findings should be interpreted with caution due to the small sample size and the use of non-validated questionnaires.

Keywords: children • hearing • hypersensitivity to sounds

NADWRAŻLIWOŚĆ SŁUCHOWA I CZYNNIKI Z NIĄ ZWIĄZANE U DZIECI W WIEKU SZKOLNYM: INTERNETOWE BADANIE ANKIETOWE OPARTE NA ODPOWIEDZIACH RODZICÓW I DZIECI

Streszczenie

Wprowadzenie: Celem badania była analiza dotycząca tolerancji na dźwięki u dzieci w wieku szkolnym 9–14 lat, przeanalizowanie różnic między grupami wiekowymi i zidentyfikowanie potencjalnych zależności.

Materiał i metody: Przeprowadzono badanie eksploracyjne o charakterze przekrojowym. Zastosowano metodę ankiety internetowej z udziałem dzieci w wieku od 9 do 14 lat oraz ich rodziców/opiekunów, zrekrutowanych za pośrednictwem mediów społecznościowych. Rodzice/opiekunowie i dzieci wypełnili oddzielne kwestionariusze; kwestionariusz opracowany dla dzieci nie został formalnie walidowany, ale stosowano go we wcześniejszych badaniach pediatrycznych. Nadwrażliwość słuchową kwalifikowano jako występującą, gdy zarówno rodzic, jak i dziecko zgłosili jej obecność. Korelacje przeanalizowano za pomocą testu Fishera, porównując osoby z nadwrażliwością słuchową pod kątem tego, czy były one również wrażliwe na światło, zapachy lub chorobę lokomocyjną. Zgodność pomiędzy ocenami rodziców i dzieci zweryfikowano z wykorzystaniem współczynnika kappa (κ).

Wyniki: Zrekrutowano 75 rodziców, jednak ostatecznie 60 dzieci wypełniło kwestionariusz (przedział wiekowy 9–14 lat; średnia 12 lat; 61,7% chłopców). Trudności ze słuchem były częściej zgłaszane u dzieci w wieku 9–10 lat ($p = 0,010$), podczas gdy dzieci w wieku 13–14 lat ($p = 0,010$) istotnie częściej korzystały ze słuchawek. Choroba lokomocyjna występowała częściej u dzieci w wieku 11–12 lat ($p = 0,033$). Szumy uszne zgłosiło 20% dzieci, a nadwrażliwość słuchową – 10,3%, przy czym nie wystąpiły istotne różnice między grupami wiekowymi. Wrażliwość na światło i zapachy była istotnie powiązana z nadwrażliwością słuchową według relacji rodziców ($p = 0,007$) i relacji dzieci ($p = 0,020$). Nie zaobserwowano związku między chorobą lokomocyjną a nadwrażliwością słuchową.

Wnioski: Częstość występowania nadwrażliwości słuchowej wśród dzieci w wieku szkolnym była stosunkowo niska, jednak występowanie dyskomfortu związanego nadwrażliwością słuchową było znaczące. W ocenie klinicznej pacjenta należy uwzględnić jego tolerancję na dźwięk. Wyniki niniejszego badania należy interpretować ostrożnie ze względu na małą liczebność próby i wykorzystanie niewalidowanych kwestionariuszy.

Słowa kluczowe: dzieci • słuch • nadwrażliwość słuchowa

Introduction

Auditory hypersensitivity can be understood as an abnormal perception of sound that negatively impacts daily life, including social and leisure activities [1]. Also referred to as sound intolerance or reduced sound tolerance, it describes discomfort when exposed to everyday sounds that are usually tolerable for most people. Three subtypes are described in the literature: hyperacusis, defined as increased sensitivity to environmental and everyday sounds [2,3]; misophonia, a negative reaction to specific patterned sounds such as chewing or tapping [4]; and phonophobia, a persistent fear of particular sounds [5].

The pathophysiology of hyperacusis remains under debate. Proposed mechanisms include altered amplification in cochlear outer hair cells [3] and dysfunction in the medial olivocochlear efferent system, leading to abnormal auditory gain and exaggerated behavioral responses to sound [7]. Hyperacusis often co-occurs with other conditions such as Williams syndrome and autism spectrum disorder [2], and it shows strong associations with tinnitus [8–11], suggesting shared neurophysiological mechanisms and broader sensory vulnerabilities [12–14].

Although more frequently described in adults, hyperacusis also occurs in children and can be distressing, with reactions ranging from mild avoidance to extreme behavioral or physiological responses [15,16]. Prevalence estimates in pediatric populations range from 3.2% to 17.1% [15], but

results remain inconsistent due to heterogeneous definitions, study designs, and the absence of validated child-specific assessment tools [2]. This contrasts with tinnitus, for which more prevalence studies exist, though estimates are variable (7.5–60%) [16].

The lack of standardized pediatric protocols makes diagnosing hyperacusis particularly challenging, as it is inherently subjective and younger children may have difficulty articulating their experiences [15]. Hyperacusis in children remains underexplored, and most available protocols are adapted from adult populations, limiting their applicability. Currently, there is no validated tool for assessing hyperacusis in children, since most questionnaires are designed for adults. Although audiological measures such as loudness discomfort levels are used in adults, no standardized pediatric protocol currently exists.

Moreover, hyperacusis is inherently subjective, only understood through the individual's own perception of everyday sounds. For this reason, self-report is considered the most valid method for capturing sound intolerance in children. Because children may under- or overreport their difficulties, and parents may misinterpret or overlook symptoms, a dual-report strategy allows for a more comprehensive assessment. Furthermore, previous studies have primarily examined clinical populations; little is known about sound tolerance in community-based samples. The internet-based survey design used here enables the recruitment of a broader sample of school-aged

subjects and provides valuable epidemiological data to help fill the existing knowledge gap.

Given the multiple challenges, self-report remains the best method for assessing hyperacusis. Nevertheless, children's accounts may differ from perceptions of their parents, with potential under- or overestimation by either party. Combining both perspectives provides a more comprehensive understanding of sound intolerance in children. Moreover, most existing research has focused on clinical populations, whereas little is known about hyperacusis and associated factors in community-based samples.

This study aims to investigate sound tolerance in school-children aged 9–14 years, examine differences across age groups, and identify possible associated factors. By using an internet-based dual-report approach, this study seeks to address the current lack of population-based data on pediatric hyperacusis and provide evidence to support early identification strategies. Given the lack of validated pediatric instruments for hyperacusis, this study was an exploratory investigation to try to characterize sound intolerance using reports from both caregivers and their children.

Material and methods

This cross-sectional study followed the STROBE statement for observational studies [17]. The study was approved by the local ethics committee of our university department (protocol no. 5.037.928) and conducted in accordance with the Declaration of Helsinki and its amendments. Informed consent was obtained from both children and their parents. Data collection occurred during the COVID-19 pandemic, and all recruitment and assessments were conducted online.

Participants

Children aged 9–14 years, regardless of gender, were eligible if they had functional auditory, visual, and cognitive capacities, access to the internet via mobile network or wi-fi, had an electronic device (notebook or smartphone), and provided informed assent. Participants were recruited through invitations distributed on social media platforms (Instagram and Facebook) addressed to parents. Children were then recruited by their parents. Questionnaires which indicated that the child had auditory hypersensitivity but where the child did not complete the specific question about triggering sounds were excluded.

Measurement tools

The two questionnaires developed by Coelho (2007) [18] – a demographic questionnaire and a two-part questionnaire used by two other studies [19,20] – were adopted. It is one of the few instruments designed to explore hyperacusis in children, although it has not been formally validated. This choice was motivated by the absence of validated pediatric measures and the need for a developmentally appropriate approach.

Parents first completed the demographic questionnaire, which included questions about sensitivity to light, odors, and motion, as well as a modified two-part questionnaire.

Table 1. Sociodemographics of the study sample ($n = 60$) by gender and education level

		<i>n</i>	%
Gender	Female	23	38
	Male	37	62
Education Level	Elementary School I	17	28
	Middle School	43	72
Age group [years]	9 to 10	14	23
	11 to 12	18	30
	13 to 14	28	47
Study sample	<i>n</i>	60	
	Mean	12.0	
	Median	12.0	
	Minimum	9.0	
	Maximum	14.0	
	Standard deviation	1.5	

Part one of the latter assessed hypersensitivity to everyday sounds using four multiple-choice questions (yes = 4, don't know = 2, no = 0). A child scoring > 8 points was classified as hypersensitive. Part two included 6 questions assessing common behavioral reactions to sounds. See the **Supplementary questionnaire**.

In turn, children completed three main questions investigating hearing loss, the presence of tinnitus, and subjective hypersensitivity to sounds. Children also had to indicate which sounds annoyed them, chosen from a list of 20 sounds. If positive answers were given to the question “Are you bothered by any kind of sound or noise?” and the child indicated 5 or more from the list of 20 annoying sounds, the child was classified as “hypersensitive to sound” [19]. All surveys were administered via Google Forms, with participants accessing them through an electronic link.

Data analysis

Statistical analyses were performed using SPSS Statistics version 28.0 (IBM Corp., Armonk, NY, USA), with a significance level of 5% ($p \leq 0.05$). Associations between categorical variables were analyzed using a Pearson's chi-square test or Fisher's exact test (including the Fisher–Freeman–Halton extension for tables larger than 2×2, when appropriate). Inter-rater agreement between parent and child reports was assessed using the kappa coefficient (κ) [20], with interpretation based on McHugh (2012) [21]. The analytical framework followed Field (2017) [22]. Given the exploratory nature of this study, multiple statistical tests were performed without correction for multiple comparisons (it is therefore acknowledged that the overall Type I error rate could exceed the nominal 5% significance level for individual tests, so some results with $p < 0.05$ may have occurred by chance). Nevertheless, only a few findings reached statistical significance. Thus, the results should

Table 2. Health of the study sample (general and auditory) based on the report of parent or guardian and stratified by age of child (9–10, 11–12, and 13–14 years)

	Age group [years]						Total	p-value		
	9 to 10		11 to 12		13 to 14					
	n	%	n	%	n	%	n	%		
Does your child have any health problem?	No	12	86	15	83	21	75	48	80	0.767 ^a
	Yes	2	14	3	17	7	25	12	20	
Do you think your child has listening difficulties?	No	10	71	18	100	27	96	55	92	0.010 ^a
	Yes	4	29	–	–	1	4	5	8	
Has your child already had audiometry?	No	6	43	6	33	13	46	25	42	0.676 ^b
	Yes	8	57	12	67	15	54	35	58	
If he/she did, was the result normal?	No	1	12	–	–	–	–	1	3	0.222 ^a
	Yes	7	87	12	100	16	100	35	97	
Has your child ever had an ear infection?	No	5	35	12	67	12	43	29	48	0.116 ^b
	Yes	9	64	6	33	16	57	31	52	
Does your child use headphones a lot?	No	8	57	8	44	4	14	20	33	0.010 ^b
	Yes	6	43	10	56	24	86	40	67	
Does your child have difficulties understanding conversations in a noisy environment?	No	9	64	14	78	20	71	43	72	0.702 ^b
	Yes	5	36	4	22	8	29	17	28	
Does your child consume a lot of sugar?	No	9	64	10	56	11	39	30	50	0.266 ^b
	Yes	5	36	8	44	17	61	30	50	
Does your child do physical exercise?	No	5	36	8	44	8	29	21	35	0.544 ^b
	Yes	9	64	10	56	20	71	39	65	
Does your child sleep well?	No	1	7	1	6	5	18	7	12	0.512 ^a
	Yes	13	93	17	94	23	82	53	88	
Does your child have learning difficulties at school?	No	13	93	15	83	23	82	51	85	0.727 ^a
	Yes	1	7	3	17	5	18	9	15	
Is your child bothered by smells and/or lights?	No	12	86	14	78	20	71	46	77	0.628 ^a
	Yes	2	14	4	22	8	29	14	23	
Does your child feel sick in the car, on the bus, or on the subway?	No	11	79	10	56	25	89	46	77	0.033 ^a
	Yes	3	21	8	44	3	11	14	23	

Note: ^a Extended Fisher's exact test, ^b Pearson's chi-square test

be interpreted with caution and considered exploratory, providing a basis for future confirmatory analyses using appropriate corrections.

Results

A total of 75 parents were recruited for the study. However, 15 were excluded because their children did not meet the eligibility criteria, resulting in a final sample of 60 schoolchildren aged 9 to 14 years (mean age 12.0 years). Of these, 37 (62%) were male and 23 (38%) were female. Regarding

educational level, 28% were in elementary school and 72% in middle school (Table 1).

Most parents reported no health problems in their children (80%). Similarly, the majority reported no listening difficulties (92%), no difficulty understanding conversations in noisy environments (72%), no sleep problems (88%), no learning difficulties (85%), no sensitivity to smells and/or lights (77%), and no motion sickness (77%), independent of age. Overall, two-thirds of the children (67%) used headphones, particularly adolescents aged 13–14 years ($p = 0.010$) (Table 2).

Table 3. Hyperacusis in the study sample, based on the reports of parents or guardians and stratified by age group (9–10, 11–12, and 13–14 years)

		Age group [years]						Total		p-value
		9 to 10		11 to 12		13 to 14		n	%	
		n	%	n	%	n	%			
Do you think your son or daughter is very sensitive to everyday sounds?	No	12	86	14	78	20	71	46	77	0.235 ^a
	Yes	1	7	4	22	8	29	13	22	
	I don't know	1	7	–	–	–	–	1	2	
Is there a sound that your son or daughter doesn't like?	No	7	50	12	67	16	57	35	58	0.342 ^a
	Yes	4	29	4	22	11	39	19	32	
	I don't know	3	21	2	11	1	4	6	10	
Is there a sound that your son or daughter finds painful?	No	13	93	16	89	21	75	50	83	0.413 ^a
	Yes	1	7	2	11	3	11	6	10	
	I don't know	0	0	0	0	4	14	4	7	
Is there a sound that scares your child?	No	12	86	15	83	21	75	48	80	0.767 ^a
	Yes	2	14	3	17	7	25	12	20	
	I don't know	0	0	0	0	0	0	0	0	

Note: ^a Extended Fisher's exact test

Table 4. Auditory health and hyperacusis in the study sample, based on children's reports, stratified by age group (9–10, 11–12, and 13–14 years)

		Age group [years]						Total		p-value
		9 to 10		11 to 12		13 to 14		n	%	
		n	%	n	%	n	%			
Do you hear well?	No	–	–	–	–	–	–	–	–	0.315 ^a
	Yes	14	100	18	100	25	89	57	95	
	I don't know	–	–	–	–	3	11	3	5	
Do you hear a noise in your ears or head?	No	9	64	14	78	23	82	46	77	0.490 ^a
	Yes	5	36	3	17	4	14	12	20	
	I don't know	–	–	1	6	1	4	2	3	
Are you bothered by any kind of sound?	No	8	57	8	44	15	54	31	52	0.718 ^a
	Yes	6	43	10	56	11	39	27	45	
	I don't know	–	–	–	–	2	7	2	3	

Note: ^a Extended Fisher's exact test

Listening difficulties were reported significantly more often by parents of children aged 9–10 years compared with older children ($p = 0.010$). Motion sickness was more prevalent among children aged 11–12 years ($p = 0.033$).

No significant differences were observed among age groups regarding parents' perception of their children's sensitivity to everyday sounds ($p = 0.235$), dislike of specific sounds ($p = 0.342$), sounds perceived as painful ($p = 0.413$), or frightening sounds ($p = 0.767$) (Table 3).

Tinnitus was reported by 20% of children, although no significant differences were observed among age groups in relation to hearing ($p = 0.315$), tinnitus ($p = 0.490$), or being bothered by sound ($p = 0.718$) (Table 4).

Hyperacusis was reported by both parents and children in 10.3% of participants. No significant differences were found among age groups, either based on parents' perception ($p = 0.851$) or children's self-report ($p = 0.267$) (Table 5).

Table 5. Hyperacusis in the study sample, based on parents/guardians and children's reports, stratified by age group (9–10, 11–12, and 13–14 years)

		Age group [years]						Total		p-value
		9 to 10		11 to 12		13 to 14		n	%	
		n	%	n	%	n	%			
Hyperacusis (parents/guardians' report)	No	12	86	14	78	21	75	47	78	0.851 ^a
	Yes	2	14	4	22	7	25	13	22	
Hyperacusis (children's report)	No	13	93	13	72	23	88	49	84	0.267 ^a
	Yes	1	7	5	28	3	11	9	15	
Hyperacusis	No	14	100	15	83	23	88	52	90	0.351 ^a
	Yes	–	–	3	17	3	11	6	10	

Note: ^a Extended Fisher's exact test

Table 6. Comparison of sensitivity to lights and odors and hyperacusis occurrences in the study sample, stratified by age group (9–10, 11–12, and 13–14 years)

		Sensitivity to light and odors				Total		p-value	
		No		Yes		n	%		
9 to 10 years	Hyperacusis (parents/guardians' report)	No	11	92%	1			50%	12
		Yes	1	8%	1	50%	2	14%	
	Hyperacusis (children's report)	No	11	92%	2	100%	13	93%	> 0.999 ^a
		Yes	1	8%	–	–	1	7%	
11 to 12 years	Hyperacusis (parents/guardians' report)	No	11	79%	3	75%	14	78%	> 0.999 ^a
		Yes	3	21%	1	25%	4	22%	
	Hyperacusis (children's report)	No	12	86%	1	25%	13	72%	0.044 ^a
		Yes	2	14%	3	75%	5	28%	
13 to 14 years	Hyperacusis (parents/guardians' report)	No	18	90%	3	38%	21	75%	0.009 ^v
		Yes	2	10%	5	62%	7	25%	
	Hyperacusis (children's report)	No	18	95%	5	71%	23	88%	0.167 ^a
		Yes	1	5%	2	29%	3	12%	
Total	Hyperacusis (parents/guardians' report)	No	40	87%	7	50%	47	78%	0.007 ^a
		Yes	6	13%	7	50%	13	22%	
	Hyperacusis (children's report)	No	41	91%	8	62%	49	85%	0.020 ^a
		Yes	4	9%	5	38%	9	15%	

Note: ^a Extended Fisher's exact test

To further illustrate the comparison between parent- and child-reported hypersensitivity, we provide a **Supplementary table 1** that presents individual-level data. Each participant is represented by a unique identifier, with corresponding information on parental and child reports of hypersensitivity, agreement status, specific sounds identified as bothersome, and the child's behavioral reactions to these sounds (e.g., covering ears, recoiling, or fleeing). This table one to see the discrepancies and concordances between informants, as well as the variety of sound triggers and coping responses reported by children.

An association was observed between sensitivity to light and odors and the presence of hyperacusis, based on both parents' reports ($p = 0.007$) and children's self-perception ($p = 0.020$). This association was particularly evident among adolescents aged 13–14 years ($p = 0.009$) (**Table 6**). No significant association was found between motion sickness and hyperacusis, either according to parents' perception ($p = 0.478$) or children's reports ($p > 0.999$) (**Table 7**).

Table 7. Comparison of motion sickness and hyperacusis occurrences in the study sample, stratified by age group (9–10, 11–12, and 13–14 years)

		Motion sickness				Total	p-value		
		No		Yes					
9 to 10 years	Hyperacusis (parents/guardians' report)	No	9	82%	3	100%	12	86%	> 0.999 ^a
		Yes	2	18%	–	–			
	Hyperacusis (children's report)	No	10	91%	3	100%	13	93%	
		Yes	1	9%	–	–	1	7%	
11 to 12 years	Hyperacusis (parents/guardians' report)	No	8	80%	6	75%	14	78%	> 0.999 ^a
		Yes	2	20%	2	25%	4	22%	
	Hyperacusis (children's report)	No	6	60%	7	88%	13	72%	0.314 ^a
		Yes	4	40%	1	12%	5	28%	
13 to 14 years	Hyperacusis (parents/guardians' report)	No	20	80%	1	33%	21	75%	0.145 ^a
		Yes	5	20%	2	67%	7	25%	
	Hyperacusis (children's report)	No	21	91%	2	67%	23	89%	0.319 ^a
		Yes	2	9%	1	33%	3	11%	
Total	Hyperacusis (parents/guardians' report)	No	37	80%	10	71%	47	78%	0.478 ^a
		Yes	9	20%	4	29%	13	22%	
	Hyperacusis (children's report)	No	37	84%	12	86%	49	85%	> 0.999 ^a
		Yes	7	16%	2	14%	9	15%	

Note: ^a Extended Fisher's exact test

Discussion

This study aimed to investigate hyperacusis in school-aged children (9–14 years) using both parental perception and children's self-assessment, and to examine whether auditory health-related factors, such as motion sickness or tinnitus, as well as hypersensitivity to light and odors, were associated with hyperacusis. Importantly, we stratified results by age, as suggested during peer review, which allowed more precise detection of age-specific patterns and eliminated previous borderline statistical associations.

At present, there is no universally accepted gold standard for the diagnosis of hyperacusis in children. Most validated questionnaires, such as Khalifa's Hyperacusis Questionnaire, were developed for adults and may not be developmentally appropriate for children. The instrument we used in this study [18] has not undergone formal psychometric validation; however, it was selected because it is one of the few tools specifically designed to explore sound intolerance in children and has been applied in previous research. Objective measures such as Loudness Discomfort Levels (LDL/ULL) are often recommended in combination with questionnaires in adults to provide supportive information, but they are difficult to administer reliably in children and are not validated as diagnostic tools for this age group. Consistent with current recommendations, we prioritized caregiver and child self-report to capture the subjective nature of hyperacusis, while acknowledging that future studies should aim to combine

structured questionnaires with behavioral or psychoacoustic measures, and to further validate instruments for use in pediatric populations.

Considering the parental questionnaire, most children were reported to be in good health (**Table 2**), with 80% having no health problems, 65% engaging in regular physical activity, and 88% reporting adequate sleep. The high prevalence of physical activity is notable, as habits formed in this period often persist into adulthood and may reduce long-term health risks.

Regarding auditory health, 92% of parents reported that their children heard well; however, 67% of children frequently used headphones, particularly in the 13–14-year-old group ($p = 0.010$). While headphone use is increasingly common, prolonged or high-volume exposure can pose auditory health risks.

Previous studies have reported an association between tinnitus in children and a history of motion sickness, suggesting a possible overlap between vestibular and auditory pathways. For instance, Coelho et al. (2007) [18] identified motion sickness as one of the significant risk factors for tinnitus in school-aged children, alongside noise exposure and hyperacusis. In our study, however, we did not find a significant association between auditory hypersensitivity and motion sickness. Instead, we observed that hypersensitivity to light and odors was more strongly related to sound intolerance, which may point

toward a broader multisensory processing vulnerability rather than a vestibular-specific contribution.

Our findings of an association between sound intolerance and sensitivity to light and odors are in line with previous studies in adults reporting co-occurrence of multisensory hypersensitivity. For instance, Nordin et al. (2013) [24] observed that individuals with noise sensitivity also showed increased odor sensitivity, and that stress played a mediating role in this relationship. This suggests that a common vulnerability across sensory systems may underlie decreased tolerance to everyday stimuli. Extending these findings to a pediatric population, our results indicate that auditory hypersensitivity in children may also be embedded in a broader sensory profile, potentially influenced by stress-related mechanisms.

Hyperacusis prevalence was 17% according to parental perception and 15% by children's self-report. Combining both criteria, 5 children were classified as hyperacusis-positive, consistent with prior pediatric prevalence studies (3–17%) [15]. Notably, 20% of children reported tinnitus, and hyperacusis and tinnitus appeared to co-occur, supporting findings in both pediatric and adult populations [8,18,20]. Age-stratified analysis revealed that younger children (9–10 years) more frequently exhibited listening difficulties, while older children (13–14 years) reported higher headphone usage. No significant differences were found between age groups regarding parents' perception of sensitivity to everyday sounds, highlighting that hyperacusis may manifest independently of age within this range.

Our results complement clinical data from Rosing et al. (2016) [25], who described referral patterns and interventions for Danish children with tinnitus and hyperacusis. While their study reflects children already referred to specialized services, our community-based findings indicate that hypersensitivity to everyday sounds and tinnitus are also reported by school-aged children outside clinical contexts. Taken together, these studies highlight two critical issues: first, parental perception plays a major role in whether children access care; second, the absence of validated pediatric assessment tools contributes to variability in both referral and management. This convergence underscores the need for standardized screening approaches that can be applied both in clinical and community settings.

Some discrepancies between parent and child reports were observed, reflecting the complexity of assessing sound sensitivity in children. Parents may interpret their child's reactions through their own expectations, whereas children may have difficulty articulating discomfort, potentially leading to underreporting. Social desirability bias may further reduce self-reported prevalence. These findings underscore the need for dual-report approaches, as parental perception alone may overestimate or underestimate actual hypersensitivity, and highlight the challenges of defining clear cutoff criteria for hyperacusis in pediatric populations.

Our findings are also in line with those of Coelho et al. (2007) [18], who investigated tinnitus in children and associated risk factors. Similar to their results, we observed

that tinnitus and sound sensitivity are present in school-aged children, highlighting the importance of considering these symptoms beyond clinical populations. Whereas their study identified potential audiological and environmental risk factors, our contribution emphasizes the value of integrating child self-reports and parental perspectives in early recognition. Together, these results suggest that systematic inquiry into tinnitus and sound hypersensitivity may facilitate timely detection and prevention strategies in pediatric populations.

The absence of misophonia or phonophobia assessment is a limitation, since these subtypes of auditory hypersensitivity were not evaluated.

Methodological considerations include reliance on self-report questionnaires without audiological confirmation and use of adapted tools that are not validated for children. The small, convenience-based, online sample limits generalizability and may introduce selection bias, though it allowed safe data collection during the COVID-19 pandemic. Also, as this study was exploratory and multiple statistical tests were conducted without correction for multiple comparisons, some statistically significant findings may have arisen by chance. These results should therefore be interpreted with caution and considered preliminary, highlighting the need for future studies with confirmatory analyses and appropriate adjustments for multiple testing.

Future research should incorporate objective auditory evaluation, including determination of uncomfortable loudness levels, and aim to develop validated pediatric hyperacusis questionnaires. Further studies should explore discrepancies between parent and child reports, the influence of social desirability, and the broader sensory environment, which may inform targeted interventions and clinical assessment strategies.

Conclusions

This study indicates that sound tolerance problems, including hyperacusis and tinnitus, occur in school-aged children, with prevalence rates of approximately 10% and 20%, respectively. No age-related differences were observed, although listening difficulties were more common in younger children and headphone use more common in adolescents. Importantly, sensitivity to light and odors was associated with hyperacusis, suggesting that auditory hypersensitivity may be part of a broader sensory vulnerability rather than an isolated phenomenon.

Although these findings provide new insights, they should be interpreted cautiously, since this is an exploratory study using a non-validated questionnaire. Future research should aim to validate pediatric-specific assessment tools and incorporate objective measures.

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References

1. Aazh H, McFerran D, Moore BCJ. Uncomfortable loudness levels among children and adolescents seeking help for tinnitus and/or hyperacusis. *Int J Audiol*, 2018; 57(9): 688–95. <https://doi.org/10.1080/14992027.2018.1470339>
2. Potgieter I, Fackrell K, Kennedy V, Crunkhorn R, Hoare DJ. Hyperacusis in children: a scoping review. *BMC Pediatr*, 2020; 20(1): 319. <https://doi.org/10.1186/s12887-020-02223-5>
3. Jastreboff PJ, Jastreboff MM. Decreased sound tolerance: hyperacusis, misophonia, diplacusis, and polyacusis. *Handb Clin Neurol*, 2015; 129: 375–87. <https://doi.org/10.1016/B978-0-444-62630-1.00022-6>
4. Cavanna AE, Seri S. Misophonia: current perspectives. *Neuropsychiatr Dis Treat*, 2015; 11: 2117–23. <https://doi.org/10.2147/NDT.S81438>
5. Asha'ari ZA, Mat Zain N, Razali A. Phonophobia and hyperacusis: practical points from a case report. *Malays J Med Sci*, 2010; 17(1): 49–51.
6. Baguley DM. Hyperacusis. *J R Soc Med*, 2003; 96(12): 582–5. <https://doi.org/10.1177/014107680309601203>
7. Jastreboff MM, Jastreboff PJ. Components of decreased sound tolerance: hyperacusis, misophonia, phonophobia. *ITHS News Lett*, 2001; 2: 1–4.
8. Jastreboff PJ, Jastreboff MM. Tinnitus retraining therapy (TRT) as a method for treatment of tinnitus and hyperacusis patients. *J Am Acad Audiol*, 2000; 11(3): 162–77.
9. Aazh H, Moore BCJ. Prevalence and characteristics of patients with severe hyperacusis among patients seen in a tinnitus and hyperacusis clinic. *J Am Acad Audiol*, 2018; 29(7): 626–33. <https://doi.org/10.3766/jaaa.17015>
10. Cederroth CR, Lugo A, Edvall NK, Lazar A, Lopez-Escamez J-A, Bulla J, et al. Association between hyperacusis and tinnitus. *J Clin Med*, 2020; 9(8): 2412. <https://doi.org/10.3390/jcm9082412>
11. Fávero ML, Sanchez TG, Bento RF, Nascimento AF. Contralateral suppression of otoacoustic emission in patients with tinnitus. *Braz J Otorhinolaryngol*, 2006; 72(2): 223–6. [https://doi.org/10.1016/s1808-8694\(15\)30059-8](https://doi.org/10.1016/s1808-8694(15)30059-8)
12. Andersson G, Lindvall N, Hursti T, Carlbring P. Hypersensitivity to sound (hyperacusis): a prevalence study conducted via the Internet and post. *Int J Audiol*, 2002; 41(8): 545–54. <https://doi.org/10.3109/14992020209056075>
13. Uneri A, Turkdogan D. Evaluation of vestibular functions in children with vertigo attacks. *Arch Dis Child*, 2003; 88(6): 510–1. <https://doi.org/10.1136/adc.88.6.510>
14. Nordin S, Neely G, Olsson D, Sandström M. Odor and noise intolerance in persons with self-reported electromagnetic hypersensitivity. *Int J Environ Res Public Health*, 2014; 11(9): 8794–5. <https://doi.org/10.3390/ijerph110908794>
15. Rosing SN, Schmidt JH, Wedderkopp N, Baguley DM. Prevalence of tinnitus and hyperacusis in children and adolescents: a systematic review. *BMJ Open*, 2016; 6(6): e010596. <https://doi.org/10.1136/bmjopen-2015-010596>
16. Nemholt S, Schmidt JH, Wedderkopp N, Baguley DM. A cross-sectional study of the prevalence and factors associated with tinnitus and/or hyperacusis in children. *Ear Hear*, 2020; 41(6): 1462–9. <https://doi.org/10.1097/AUD.0000000000000858>
17. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *J Clin Epidemiol*, 2008; 61(4): 344–9. <https://doi.org/10.1016/j.jclinepi.2007.11.008>
18. Coelho CB, Sanchez TG, Tyler RS. Tinnitus in children and associated risk factors. *Prog Brain Res*, 2007; 166: 179–91. [https://doi.org/10.1016/S0079-6123\(07\)66016-6](https://doi.org/10.1016/S0079-6123(07)66016-6)
19. Ralli M, Romani M, Zozda A, Russo FY, Altissimi G, Orlando MP, et al. Hyperacusis in children with attention deficit hyperactivity disorder: a preliminary study. *Int J Environ Res Public Health*, 2020; 17(9): 3045. <https://doi.org/10.3390/ijerph17093045>
20. Ralli M, Greco A, Altissimi G, Tagliaferri N, Carchiolo L, Turchetta R, et al. Hyperacusis in children: a preliminary study on the effects of hypersensitivity to sound on speech and language. *Int Tinnitus J*, 2018; 22(1): 10–18. <https://doi.org/10.5935/0946-5448.20180002>
21. Cohen J. A coefficient of agreement for nominal scales. *Educ Psychol Meas*, 1960; 20(1): 37–46. <https://doi.org/10.1177/001316446002000104>
22. McHugh ML. Interrater reliability: the kappa statistic. *Biochem Med (Zagreb)*, 2012; 22(3): 276–82.
23. Field A. *Discovering Statistics Using IBM SPSS Statistics* (North American Ed.). Thousand Oaks: Sage Publications; 2017.
24. Nordin S, Körning Ljungberg J, Claeson A-S, Neely G. Stress and odor sensitivity in persons with noise sensitivity. *Noise Health*, 2013; 15: 173–7. <https://doi.org/10.4103/1463-1741.112366>
25. Rosing SN, Kapandais A, Schmidt JH, Baguley DM. Demographic data, referral patterns and interventions used for children and adolescents with tinnitus and hyperacusis in Denmark. *Int J Pediatr Otorhinolaryngol*, 2016; 89: 112–20. <https://doi.org/10.1016/j.ijporl.2016.07.036>

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Supplementary questionnaires

Sociodemographic Questionnaire for Parents

1. **Gender**
 - a. Male
 - b. Female
2. **Age**
3. **Does your child have any health problems?**
 - a. Yes
 - b. No

If yes, which of the following?

 - a. Diabetes
 - b. High blood pressure
 - c. Asthma
 - d. Migraine
 - e. Attention deficit
 - f. Epilepsy
 - g. Auditory processing disorder
 - h. Autism
 - i. Other (please specify): _____
4. **Do you believe your child has difficulty hearing?**
 - a. Yes
 - b. No
- Has your child ever undergone an audiometry test?**
 - a. Yes
 - b. No

If yes, were the results normal?

 - a. Yes
 - b. No
6. **Has your child ever had an ear infection?**
 - a. Yes
 - b. No

If yes, how many times? _____
7. **Does your child frequently use headphones?**
 - a. Yes
 - b. No

If yes, for how many hours per day? _____
8. **Does your child have difficulty understanding speech in noisy environments?**
 - a. Yes
 - b. No
9. **Does your child consume a lot of sugar?**
 - a. Yes
 - b. No
10. **Does your child engage in physical exercise?**
 - a. Yes
 - b. No
11. **Does your child sleep well?**
 - a. Yes
 - b. No
12. **Does your child have learning difficulties at school?**
 - a. Yes
 - b. No
13. **Is your child sensitive to smells and/or lights?**
 - a. Yes
 - b. No
14. **Does your child experience motion sickness in cars, buses, or subways?**
 - a. Yes
 - b. No

Questionnaire for Parents

1. **Do you think your child is very sensitive to every-day sounds?**
 - a. Yes
 - b. No
 - c. I don't know
2. **Is there any sound your child dislikes?**
 - a. Yes
 - b. No
 - c. I don't know
3. **Is there any sound your child finds painful?**
 - a. Yes
 - b. No
 - c. I don't know
4. **Is there any sound that scares your child?**
 - a. Yes
 - b. No
 - c. I don't know
5. **Indicate your child's most frequent reaction to sounds:**
 - a. Covers their ears
 - b. Cries
 - c. Runs away from the sound
 - d. Pulls back to avoid the sound
 - e. Says "I don't like this sound" or "This sound hurts"
 - f. Other (please specify): _____

Children's Questionnaire

1. Do you hear well?

- a. Yes
- b. No
- c. I don't know

2. Do you hear a noise in your ears or in your head?

- a. Yes
- b. No
- c. I don't know

3. Does any kind of sound bother you?

- a. Yes
- b. No
- c. I don't know

4. Do any of these sounds bother you?

- a. Recess
- b. Classroom noise
- c. Screaming
- d. School bell
- e. TV
- f. Radio
- g. Blender
- h. Telephone
- i. Car
- j. Motorcycle
- k. Truck
- l. Ambulance
- m. Toy
- n. Balloon
- o. Whistling
- p. Musical instruments
- q. Fireworks
- r. Firecrackers
- s. Thunder
- t. Dog barking

Supplementary table 1. Individual-level data on hypersensitivity: parental and child reports, agreement status, bothersome sounds, and children's behavioral reactions

Child ID	Age	Parent-reported hypersensitivity	Child self-reported hypersensitivity	Agreement	Annoying sounds reported	Reactions to sounds
1	13–14	No	Yes	No	F, L	01
2	11–12	No	Yes	No	C	None
3	11–12	No	Yes	No	C, G, I, J, L	02
4	9–10	No	Yes	No	None	05
5	13–14	No	Yes	No	N	02
6	11–12	No	Yes	No	C	None
7	13–14	No	No	No	C	None
8	11–12	No	Yes	No	C	None
9	13–14	No	No	No	None	02
10	11–12	Yes	Yes	Yes	B, C, D, G, J, N, Q, R, S	02
11	9–10	Yes	Yes	Yes	J, K	02
12	9–10	No	No	No	None	None
13	11–12	Yes	Yes	Yes	C, D, F	02
14	13–14	Yes	No	No	None	02
15	9–10	No	No	No	None	01
16	9–10	No	No	No	None	05
17	13–14	No	Yes	No	None	03
18	13–14	No	Yes	No	C, H, J, T	01
19	9–10	No	Yes	No	C, J	05
20	13–14	No	No	No	S	None
21	9–10	No	Yes	No	B, C, D, F, J, K, L, Q, T,	None
22	13–14	No	No	No	H, S	05
23	9–10	No	No	No	F	02
24	9–10	No	Yes	No	None	05
25	13–14	Yes	Yes	Yes	B, C, F, J, O, R	01
26	13–14	No	No	No	None	None
27	13–14	Yes	No	No	None	02
28	11–12	No	No	No	G	05

Supplementary table 1 continued. Individual-level data on hypersensitivity: parental and child reports, agreement status, bothersome sounds, and children’s behavioral reactions

Child ID	Age	Parent-reported hypersensitivity	Child self-reported hypersensitivity	Agreement	Annoying sounds reported	Reactions to sounds
29	11–12	No	Yes	No	None	05
30	13–14	No	No	No	C, T	03
31	13–14	No	No	No	None	None
32	11–12	No	No	No	None	None
33	13–14	No	No	No	C, F, R	None
34	13–14	Yes	No	No	None	04
35	11–12	Yes	Yes	Yes	C, J, L, N, R, S	05
36	11–12	No	Yes	No	C, H, I, J, K, L, M	02
37	11–12	No	No	No	None	None
38	13–14	No	Yes	No	None	05
39	13–14	No	No	No	None	None
40	13–14	No	Yes	No	C, J	None
41	9–10	No	No	No	G, L, S	01
42	13–14	Yes	Yes	Yes	J, K, N	02
43	13–14	No	No	No	None	04
44	13–14	No	No	No	R	02
45	9–10	No	No	No	None	None
46	13–14	No	No	No	None	None
47	13–14	Yes	Yes	Yes	None	02
48	11–12	Yes	Yes	Yes	C, F, L, M, S, T	02
49	11–12	No	No	No	None	01
50	9–10	No	Yes	No	S	None
51	11–12	No	No	No	None	05
52	9–10	No	No	No	C, F, K, T	02
53	13–14	No	No	No	G	05
54	11–12	No	No	No	K, L, R, S	None
55	9–10	No	No	No	N	02
56	13–14	Yes	Yes	Yes	B, C, D, G, J, K, S	02
57	13–14	No	No	No	None	02
58	11–12	No	No	No	None	05
59	11–12	No	No	No	B, K	01
60	13–14	Yes	Yes	Yes	B, G, J, L, T	02

Note: Numbers 1 to 60 indicate ID of child. Types of annoying sounds: A – Recess; B – Classroom noise; C – Screaming; D – School bell; E – TV; F – Radio; G – Blender; H – Telephone; I – Car; J – Motorcycle; K – Truck; L – Ambulance; M – Toy; N – Balloon; O – Whistling; P – Musical instruments; Q – Fireworks; R – Firecrackers; S – Thunder; T – Dog barking. Reactions to sound: 01 – Move away to avoid the sound; 02 – Covers the ears; 03 – Says “I don’t like that sound”; 04 – Runs away from the sound; 05 – Others