

## Review Article

# Auditory Hypersensitivity in Children with Lyme Disease

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## Abstract

Four cases of children with Lyme disease having auditory hypersensitivity are presented. Auditory testing revealed no consistent pattern of problems except for the low loudness discomfort levels (LDL) found. Medical professionals who see children with Lyme disease should consider audiological testing to include LDL measures. Treatments for auditory hypersensitivity are discussed.

## AUDITORY PROBLEMS IN CHILDREN WITH LYME DISEASE

Parents who have children with Lyme disease are very concerned with the impact of the disease on their children's bodies. One factor that is not well addressed with such children is how the Lyme disease may affect the child's abilities to process what is heard. Hearing abilities relate to two factors. One is threshold sensitivity, and hearing loss has been reported in some people with Lyme disease [1]. For example, [2] reported that hearing problems were found in 48% of patients with late stage Lyme disease. The other factor is auditory processing which has to do with how we take in and use the auditory information we hear.

One aspect of auditory processing seen with people who have Lyme disease is hypersensitivity to sound [1-5]. Auditory hypersensitivity relates to a person being overly sensitivity to sound. The University of California Medical Center at San Francisco has a website focusing on auditory hypersensitivity which they define using another term called hyperacusis. Hyperacusis is defined by them as "a reduced tolerance and increased sensitivity to everyday sounds" [6,7]. Some sounds can be everyday ones such as doors closing or children crying [3]. Baguley [8] describes hyperacusis as intolerance to ordinary, environmental sounds that lead to the person with hypersensitive hearing to react inappropriately compared with how other people with the same normal hearing would react to such sounds. Often, the reactions are autonomic nervous system responses such as in the "fight or flight" reaction a person may have when frightened. In such cases, some have referred to this over sensitivity as phonophobia or misophonia [9].

Research has demonstrated that people with Lyme disease who report they were able to tolerate sounds prior to contracting the disease notice an intolerance to loud sounds afterwards [2,4,5]. This intolerance can become so severe that it has even led to people taking their own lives [3].

Some research has been done looking specifically at the auditory manifestations of people after they have contracted Lyme disease. Shotland et al. [5] reported a reduction in loudness tolerance in 31% of their subjects. They further reported this reduced loudness tolerance was seen in many subjects in spite of having normal hearing or minimal loss of hearing. Bamio, Musiek, & Luxon [4] stated that auditory processing deficits (APD) could be due to Lyme disease and may remain with these people long after treatment of the disease has been successful. What is missing from their study is that they do not indicate the specific types of auditory processing problems present in people with Lyme disease or whether the problems were seen in adults, children or both age groups.

In the course of the author's clinical work, he has met some children who contracted Lyme disease and for whom concerns were observed with these children having difficulties listening and understanding what they heard. One group of patients included three children all from the same family who contracted Lyme disease after going on a family camping trip. The other patient is a high school student who noticed problems listening and "hearing" one year after he had been treated for Lyme disease. When discussing the medical histories regarding these four cases, the parents and adolescent reported that they were told by the children's primary care physicians about the Lyme disease and the treatment for the disorder, they were told of some of the behavioral manifestations they may encounter, but they were never told by their medical doctors about auditory problems they might experience once the medical professionals identified that their hearing was normal. Thus, it appeared that hearing loss was the only focus of hearing concern raised by the medical professionals, but their doctors never discussed problems with auditory intolerance also known as auditory hypersensitivity. Yet, all four of these patients have significant hypersensitivities to sound which might be treatable. The following is a discussion of the auditory processing results found for these four cases with

a general discussion of what might be recommended regarding treatment. For all cases, parents provided written informed consent allowing their children's records to be used in this study.

## CASE STUDIES

### Case of a 16 year old, high school student

The first case is of a 16 year old, high school student. He began noticing problems understanding his teachers in class and even conversations with his friends, especially when there were noises present, about a year after having been diagnosed with Lyme disease. His complaints led his mother to bring her son to his primary care physician.

Background information of this boy indicated that he lived in the state of Maryland and had gone camping with his family in the mountain area of West Virginia not far from Harpers Ferry, WV. The family spent a summer vacation in that area including outdoor camping one weekend of that summer. However, the symptoms leading to the boy seen by his medical doctor were not noticed until about three months after the family returned from their summer vacation. The boy complained of joint pain, intolerance to sound, being annoyed by the noises in the street and at school, and difficulties listening in class and in conversations when there are other noises present, especially loud, background noises.

When the boy's medical doctor checked him out, the lab tests verified that he had Lyme disease. The doctor told the parents that he suspected the boy had been bitten by a tick during one of the family's outings during their camping trip in the mountains of West Virginia. The doctor believed that the boy had been infected with *Borrelia burgdorferi* bacterium due to being bitten by a black-legged tick called *Ixodes scapularis* which led to him developing Lyme disease. The doctor then prescribed the use of antibiotics to cure the Lyme disease and reduce the symptoms.

The medical doctor also checked the boy's ears via otoscopic examination finding they looked normal and referred the mother to have the boy's hearing tested by an audiologist. The audiologist completed a standard hearing evaluation including pure tone and speech (SRT) thresholds, word recognition testing in quiet, otoacoustic emission testing (OAE), and middle ear immittance testing (tympanometry). Audiological testing revealed normal hearing thresholds and normal middle ear functioning as well as excellent word recognition in quiet. Thus, there were no hearing problems for the child. Furthermore, the parents and the boy reported that he had no symptoms of upper respiratory infection or allergies or exposure to loud sounds. Therefore, the normal hearing findings did not explain why the boy was having problems tolerating loud sounds and background noises.

As the boy continued to complain of difficulties hearing and understanding teachers in school and friends in conversations, the mother decided to bring her son to the author for hearing and auditory processing testing suspecting he had a hearing loss although previous hearing evaluations revealed no problems with his hearing.

Results of the hearing testing indicated he had normal hearing via pure tone air and bone conduction audiogram testing in both ears consistent with the previous hearing tests. However, loudness discomfort level (LDL) testing was well below

normally expected levels (see Lucker, 2013) [9]. When asked about this low level of tolerance, he reported that this was one of the listening problems he noticed during the past few months. He stated that prior to this time, he had no problems tolerating loud sounds, but now, a little over one year post treatment for Lyme disease, he found he could not tolerate loud noises such as traffic noise, motorcycles, sirens from fire trucks and ambulances, and even his friends calling to each other.

Results of the auditory processing tests for this subject are presented in (Table 1). Information in that table indicates normal findings vs. abnormal findings for each of the APD measures. As can be seen from this table, LDL results revealed significantly lower than normally expected [9]. However, results of speech understanding in noise tests were normal so the annoying effect reported for background noises did not interfere with the boy's abilities to understand speech in noise. Other than the LDL problem, the only deficit found on APD tests was with organization (i.e., difficulties repeating back a series of words heard in the same order in which they were heard, but being able to repeat back all of the correct words in a different order). Otherwise, his auditory processing abilities were found to be normal except for the hypersensitivity.

### THREE CHILDREN FROM THE SAME FAMILY

The second case report is of three children from the same family. The children were a 7 year old boy, a 9 year old girl, and a 12 year old girl. They came in for the auditory processing testing six months after they had been diagnosed with and treated for Lyme disease by their pediatrician. The parents reported noticing difficulties with all three children listening and understanding what they heard starting a few months after the Lyme disease was diagnosed and treatment for the Lyme disease was started.

The Lyme disease was diagnosed in the three children after returning from a family camping trip in the Blue Ridge Mountains

**Table 1:** Audiological and auditory processing test findings in four children with Lyme disease. Results are indicated only for those measures that were abnormal (Low for LDL is abnormal). All other measures were normal as noted at the end of the table.\*

Measures	Case 1	Case 2	Case 3	Case 4
Age in Years	16	7	9	12
Gender	Male	Male	Female	Female
LDL	Low	Low	Low	Low
WRS-N	Normal	Normal	Abnormal	Normal
SCAN-3 Test				
Filtered Words	Abnormal	Normal	Normal	Normal
Auditory Figure-Ground	Normal	Normal	Abnormal	Normal
Competing Words	Abnormal	Normal	Normal	Normal
Ear Diff.	Abnormal	Normal	Normal	Normal
SSW Test				
RC condition	Abnormal	Normal	Normal	Normal
Reversals	Abnormal	Normal	Abnormal	Normal

\*Normal findings for all four subjects for: Hearing thresholds, immittance measures, word recognition in quiet, SCAN-3 and SSW all other measures not listed, Comprehensive Test of Phonological Processing, and the Auditory Continuous Performance Test

west of their home in the state of North Carolina. The parents remembered that three of their children had noticeable rashes on the calves of their legs when the family was on their camping trip. The children reported that they believed the rashes came from the children scrapping their legs and scratching the area where they were scrapped. The parents also noticed that the children were complaining of joint pain and irritability to things touching them as well as complaints tolerating loud sounds and background noises. They complained that they could not tolerate things like recess at school, the noise level in the gym, or trying to follow and understand what people were saying to them in the noisy halls at school, in the lunch room, and in other noisy listening environments.

The mother reported that when she had complained about all of these problems with the joint pain, touch sensitivity, and listening problems to the children's pediatrician, the pediatrician was concerned with the rashes and the joint pain and feelings of being irritable but not the hearing problems. The pediatrician had all three children seen for a complete physical examination. Included with the examination was a series of blood tests the pediatrician ran because she suspected that the children may have been bitten by ticks carrying some disease that might cause things like Rocky Mountain spotted fever or Lyme disease. The blood tests came back normal for the three children. The pediatrician believed that the children had positive indications of Lyme disease caused by a deer tick bite (*amblyomma americanum*), and began antibiotic treatments for the three children with Lyme Disease.

Over the course of the six months, the children were reported to have improvements in their joint pain and irritability to touch, but the children still complained about tolerance to sound and misunderstanding what they heard, especially in school. This led the mother to bring the children to an audiologist to rule out hearing loss. The audiologist completed a standard hearing evaluation of pure tone and speech (SRT) thresholds as well as word recognition testing in quiet and middle ear immittance testing (tympanometry). Results of the audiological testing revealed normal hearing and normal middle ear functioning for all three children. It was not until the parents noticed the children constantly misunderstanding what they heard or complaining about sounds being "too loud" that they contacted the author, a professional specializing in auditory processing. Results of the hearing and auditory processing testing completed for the three children are also presented in (Table 1).

Hearing thresholds for air and bone conduction audiogram measures were normal for all of the children as identified on the prior audiological evaluation. However, LDL measures were significantly lower than normally expected. Only one of the children (the 9 year old) had problems on measures of speech understanding in noise. One other (12 year old) revealed a pattern of problems related to auditory integrative processing (i.e., a type of auditory processing disorder (APD) in which listening to different words in both ears and reporting the two words heard cannot be appropriately accomplished by the listener). This same one also revealed problems with organization. Except for lower than normally expected LDLs, the third child revealed no problems with any of the other measures of auditory processing.

## CONCLUSIONS

From review of these four cases, what was found was that all four had problems with loudness tolerance (lower than normally expected LDLs) [9]. One had problems with speech understanding in noise, another had auditory integration processing problems, while two others had problems with organization. Thus, what these four cases support is a conclusion that it is likely that children who contract Lyme disease may have problems with auditory hypersensitivity and other possible auditory processing deficits (APD). Overall, the present four cases do not support a conclusion that people who contract Lyme disease should expect to have auditory processing problems as suggested from the research by Bamiou, Musiek, and Luxon [4]. The findings only reveal a consistent pattern of auditory hypersensitivity in these cases. The findings, however, do agree with Shotland, et al. [5] who found that the greatest auditory difficulty with their 18 patients with post-treatment Lyme disease was auditory hypersensitivity. The findings also agree with other literature indicating that people with Lyme disease may have auditory hypersensitivity (Baiata, 2009); Keate, 2010; Lyme Disease Action, 2011) [1-3].

## TREATMENT FOR AUDITORY HYPERSENSITIVITY

One of the important factors in treating patients is whether there are programs to improve any deficits that may be found. In the case of these four clients, they were all found to have auditory hypersensitivity. There have been two treatments used with people having auditory hypersensitivity. One focuses on desensitizing the person using what psychologists refer to as systematic desensitization [10]. The other is using a listening therapy or sound intervention which may reduce negative emotional reactions when listening to loud and annoying sounds so that hypersensitivity can be reduced ([9,11]; [www.thelisteningprogram.com](http://www.thelisteningprogram.com)). Thus, a combination of these two approaches was suggested and tried with these four cases. From the parents' reports for the cases presented here, after completing the listening therapy (i.e., The Listening Program, [www.thelisteningprogram.com](http://www.thelisteningprogram.com)), all four children were reported to have less hypersensitivity and negative behavioral reactions to loud and annoying sounds. For these cases, the only desensitization used was to slowly involve the children in hearing loud and annoying sounds starting with a short period of listening to loud sounds to longer listening periods. Thus, what these four cases demonstrate is that when a child is identified as having auditory hypersensitivity to sound following a diagnosis of and treatment for Lyme disease one should evaluate the child's tolerance of loud sounds to determine whether the child has hypersensitive hearing, and then consider using a listening therapy and desensitization approach to improve tolerance of loud and annoying sounds.

The focus of this paper was to highlight the importance of considering auditory hypersensitivity as a problem when medical professionals see children who have contracted Lyme disease. These treatment options seem to help reduce the annoying effects of loud sounds and, thus, provide better listening for such children. Thus, medical professionals should let patients and families know that children and adolescents identified with Lyme disease may become overly sensitivity to loud sounds. Thus, if

listening or sound tolerance problems are noticed, the medical professionals should refer such patients to audiologists who should do not just measure hearing threshold and middle ear functioning, but should perform measures of loudness tolerance (i.e., LDL measures). If reduced loudness tolerance is found, recommendations for treatments such as listening therapies and sound desensitization should be considered.

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