

## ORIGINAL ARTICLE

## TINNITUS RISK FACTORS AND TREATMENT IN ADOLESCENTS

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Received: 21 March 2023

Revised: 30 April 2023

Accepted: 11 June 2023



Check for updates

**Funding information:**

The authors received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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**Competing interests:**

The authors have declared that no competing interests exist

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**Summary**

**Introduction:** Tinnitus is conscious perception of sound without an external sound stimulus. The origin of the name has its root in the Latin word *tinnire* (to ring). The sound can be buzzing, ringing, hissing, and is rarely heard as voice, music, or several different sounds simultaneously. Tinnitus occurs in one-third of people at least once in their lifetime and is chronic in 10-15% of the adult population. In children and adolescents aged 5 to 19 years, the range of tinnitus prevalence is quite wide (from 5% to over 40%), depending on how tinnitus is defined in the study. This article aims to provide an up-to-date overview of tinnitus risk factors and treatment in adolescents.

**Methods:** The authors searched PubMed, Embase, and Cochrane Review databases using the following keywords: *tinnitus*, *adolescents*, *risk behavior*, *risk factors*, and *treatment*. The inclusion criterion has an article published in Serbian or English without time restriction.

**Results:** Common risk factors for tinnitus among adolescents are female gender, noise exposure, hearing loss, marijuana and tobacco smoking, exposure to second-hand smoke, and sleep deprivation. Recently, some nutritional risk factors have been added: reduced water intake, niacin and protein deficit, and consumption of fizzy drinks, fast food, and white bread. The results of the current tinnitus treatments, including pharmaceutical, surgical, and behavioral ones, are unsatisfactory, causing frustration both in patients and physicians. Currently, there is no registered medicine for tinnitus.

**Conclusion:** Tinnitus is one of the greatest enigmas of modern medicine. As tinnitus is still considered incurable, we point out major risk factors among adolescents that should be targeted in primary prevention.

**Key Words:** tinnitus, adolescents, risk behavior, risk factors, treatment

## INTRODUCTION

Tinnitus is a conscious perception of sound in the absence of actual sound stimuli (1). The name originates from the Latin *tinnire* – to ring (2). It is mainly perceived as ringing, jingling, wheezing, buzzing, and sometimes as voice, music, or even multiple sounds simultaneously. Two main types of tinnitus are subjective tinnitus, where sound is perceived only by the patient, and objective tinnitus, where it can also be heard by the doctor (3). The pathophysiological mechanism of subjective tinnitus is still unknown. On the other hand, objective tinnitus can be caused by carotid or vertebral artery stenosis, myoclonic contraction of the tensor tympani muscle, abnormal contraction of nasopharyngeal muscles, etc. (3) Sound-causing objective tinnitus originates from the body itself where it is transferred to the ear where the impulse is generated and then conducted via the acoustic nerve to the auditory cortex. Since this sound has its source, by eliminating it, the perception will be eliminated (3). On the other hand, with subjective tinnitus, this can't be done. In half of all cases, tinnitus presents bilaterally. When presented unilaterally, it is more frequently perceived in the left ear (4). Rarely, the sound is perceived in the middle part of the head (4).

Every third person reported to have had tinnitus at least once in a lifetime. The chronic form of tinnitus is reported in 10-15% of adults (5,6). Data on the prevalence of tinnitus in children and adolescents are very inconsistent, ranging from 4.7% to 46% (7). This wide range is caused by differences in the methodology of different studies as well as characteristics of the pediatric population since data collected from preschool and elementary school children can be unreliable. Low prevalence is explained by the fact that children rarely report this symptom unless directly asked (8-10). On the other hand, lack of objectivity in this age group, as well as the tendency to overestimate the frequency of this symptom is considered to be the reason for certain studies to have reported a high frequency of tinnitus in this population.

As opposed to this younger pediatric population, data on tinnitus prevalence in adolescents are considered to be somewhat more reliable. In the most recent study conducted among Belgrade adolescents, Tomanic et al. (11) determined that around 13% of high school students presented with constant tinnitus, which is significantly more compared to Swedish adolescents (6%) (12), but much less compared to their Turkish peers (28.3%) (13).

Earlier, tinnitus was almost always associated with hearing loss in the elderly. However, due to the contemporary lifestyle, individuals are exposed to a more significant number of potential risk factors which increase the risk of tinnitus development, especially in healthy young adults. Nowadays, harmful effects of socioeconomic, ecological, behavioral, hereditary, and dietary factors are recognized.

Despite its high prevalence among children, tinnitus unaccompanied by hearing loss is not recognized enough in this population. Considering the fact that psychophysical well-being is essential for proper growth and development, the issue of tinnitus in this sensitive period can be considered a public health problem of particular interest.

This review aims to present known risk factors as well as tinnitus treatment in adolescents.

## METHODS

### Search Strategy

Two independent authors researched *Medline*, *Embase*, and *Cochrane* databases without time restriction. Articles in Serbian and English were considered. Book chapters found in relevant journal articles were also reviewed. The following keywords were used: *tinnitus*, *adolescents*, *risk behavior*, *risk factors*, and *treatment*. Due to method heterogeneity in the selected studies, only a narrative synthesis of the results was performed.

## RESULTS OF THE RELEVANT LITERATURE REVIEW

### Risk Factors

Earlier studies have shown a correlation between tinnitus and ear damage, especially damage related to hearing loss (14-16). However, in recent decades, studies have proven that tinnitus occurs in other auditory and non-auditory diseases as well (17). Also, a more significant number of risk factors for tinnitus development have been recognized, to which younger population is especially exposed (**Table 1.**)

### Genetic factors

Studies on the prevalence of the hereditary form of tinnitus are very rare. A large study conducted on 198 families in Europe (18) showed that tinnitus was 1.7 times more likely to occur in individuals whose brother or sister had also reported having tinnitus. In a study from 2017 conducted by Maas et al. on twins in Sweden (Swedish Twin Registry) born between 1900 and 1985, tinnitus cases were classified into subtypes according to laterality (unilateral versus bilateral); they found that chances of inheriting bilateral tinnitus were 0.56, and for unilateral tinnitus 0.27 (19). In a recent study in Serbia, heredity had a significant effect on the probability of tinnitus development (20). Tinnitus was more common in adolescents whose close relatives had some form of tinnitus (acute, constant, intermittent or occasional tinnitus) ( $p=0.036$ ) (20).

**Table 1. Tinnitus risk factors in adolescence**

| Auditory factors  | Non-auditory factors   |
|---|--|
| Hearing impaired <ul style="list-style-type: none"> <li>• Hearing loss</li> <li>• Presbycusis</li> </ul>  | Age and gender: <ul style="list-style-type: none"> <li>• Older teen ages</li> <li>• Female gender</li> </ul>   |
|   | Genetic factors (a more frequent occurrence in siblings)   |
|   | Behavioral factors: <ul style="list-style-type: none"> <li>• Noise exposure (being in noisy places, headphone use)</li> <li>• Active tobacco smoking</li> <li>• Passive tobacco smoking</li> <li>• Drug use (primarily marijuana)</li> <li>• Gambling</li> </ul> |
|   | Dietary factors: <ul style="list-style-type: none"> <li>• Positive correlation: fizzy drinks, fast food, coffee</li> <li>• Negative correlation: fruit, vegetables, wholegrain bread</li> </ul>  |
|   | Psycho-emotional factors <ul style="list-style-type: none"> <li>• Anxiety or depression</li> <li>• Insomnia</li> </ul>   |
| Specific diseases and pathological conditions associated with tinnitus: <ul style="list-style-type: none"> <li>• High blood pressure</li> <li>• Thyroid disease</li> <li>• Head and neck injuries</li> <li>• Different types of surgeries</li> <li>• Multiple sclerosis</li> <li>• Viral infections</li> <li>• Auditory nerve tumors</li> <li>• Ototoxic medicines (quinine and aspirin) use</li> <li>• Anemia</li> <li>• Hyper-/hypothyroidism</li> <li>• Hyperinsulinemia and others</li> </ul> |  |

## Age and gender

When considering age and gender, recent meta-analyses and systematic reviews have shown that females of the pediatric population have a higher risk ratio (1.37) for tinnitus development compared to males (21). Multiple publications that studied tinnitus frequency also considered gender distribution and found that tinnitus prevalence in boys was between 20% and 35.6% and in girls between 17% and 42.4% (22-26). In the first Serbian study of tinnitus in adolescents, conducted in 2013, it has been noted that girls suffered from tinnitus more frequently than boys (15% vs. 9%) (27).

Park et al. found that children aged 12 to 18 years had a higher tinnitus prevalence than other age groups (28). In their research of the pediatric population with normal hearing, Aksoy et al. found that children aged 12 to 14 most often reported tinnitus, while 16-year-olds complained least often (29). In a study by Widen and Erlandsson on over 1000 adolescents from Sweden, aged 13 to 19 years, the prevalence of tinnitus was found to be about 8%, and this symptom was more frequent in older adolescents compared to younger adolescents (30).

## Hearing impaired

Impaired hearing is still considered one of the most important risk factors associated with tinnitus. According

to Baguley, hearing loss followed by subsequent neurological compensation along the auditory pathway is the most probable model of tinnitus development (31). A number of studies indicate that tinnitus is more common among children with hearing loss compared to children with normal hearing (32, 33). In his study from 2018, Lee found that the prevalence of tinnitus in adolescents with and without hearing loss differed, with a risk ratio of 2.39 (34). Other studies also support a higher prevalence of tinnitus in children with impaired hearing (between 23.5% and 62.2%) compared to peers with normal hearing (7.5% and 46.0%) (35-37). The most recent meta-analysis by Lee and Kim emphasizes that the most significant tinnitus risk factors in adolescents were noise exposure (OR= 11.3), hearing loss (OR= 2.4), female gender (OR= 1.4), and older ages (34).

## Behavioral factors

Even though numerous studies have shown that noise exposure is a clear risk factor for tinnitus development, as well as a symptom that impairs quality of life to a large degree, adolescents do not seem to acknowledge its importance. During YANS questionnaire validation in Serbia, Tomanic et al. noted that an extremely high number of responses to the question about not needing to use earplugs in clubs and other noisy places indicates that awareness of the harmful effects of noise is very low among young people (38). The high prevalence of smoking, alcohol and substance abuse,

in adolescents with tinnitus, was noted in numerous studies (12,27,34). Several extensive cohort studies have confirmed that apart from active smoking, passive smoking, i.e. staying in rooms filled with tobacco smoke, is a very significant risk factor for tinnitus in the pediatric population (28,39-40). In their study, Lee and Kim also confirmed a significant correlation between active smoking and tinnitus in adolescents (41). Due to the specific developmental period, adolescents are more susceptible to the harmful effects of tobacco smoke and damage to the electromechanical transduction of external auditory cells may be more severe than in older smokers (42).

In the study by Marmut et al., the most dominant tinnitus risk factor in boys was drug use, primarily marijuana (OR = 13.1), whereas in girls it was passive smoking (OR 1,3/ per two hours of exposure) (27). Another study conducted six years later in Serbia found a positive correlation between tinnitus and drug use, being in noisy places, high blood pressure, headphone use, head injury, anxiety or depression, thyroid disease, and smoking (20). Tinnitus was also negatively affected by sedative use, anemia, sinusitis, noise exposure at home, duration of night sleep and noise exposure at school, but these correlations were not statistically significant (20).

### Dietary factors

The correlation between nutritional factors and tinnitus in children and adolescents has not been investigated so far. In spite of growing interest and numerous studies in tinnitus, only a few studies researched the correlation between dietary factors and tinnitus and mostly in adult population. The study conducted by Tomanic et al. in 2020 was the first publication that examined the connection between dietary factors and tinnitus in an adolescent population (11). These authors found that fresh fruit, vegetables, and wholegrain bread intake may be negatively correlated to tinnitus, while fizzy drinks and fast food may raise the odds of tinnitus in adolescents (11).

### Psycho-emotional factors

In one-third of adolescents, tinnitus is associated with significant psycho-emotional factors (anxiety and depression), which must be recognized and treated (43). Indeed, Levi et al. confirmed that psychiatric disorders in adolescence acted as risk factors for tinnitus (43). According to Nagel, tinnitus may be a cause of anxiety, depression, and insomnia and can impair life quality in younger people (44). At the same time, Stallman recognizes tinnitus as a severe symptom that often leads to a decrease in overall functionality and aggravates achieving academic results in the student population (45). Populational study in Korea indicated that an additional tinnitus risk factor was the average length of sleep  $\leq 6$  hours (AOR = 1.7) compared to  $\geq 9$  hours (21). The problem of not achieving an

adequate sleep length is recognized in adolescents worldwide, as well as in Serbia, where it is found that 32.6% of boys and 27.6% of girls sleep less than recommended for this age group (46). Tomanic et al. also found a statistically positive correlation between gambling and tinnitus development in Belgrade high schoolers (20).

### Specific diseases and pathological conditions associated with tinnitus

Tinnitus in all age categories can be an accompanying symptom of various diseases, resulting from taking numerous medications after head and neck injuries, different types of surgeries, excessive noise exposure, and numerous other causes (2). As mentioned before, tinnitus is a very significant symptom of hearing loss (47,48). It can also occur due to specific physiological processes in the inner ear, such as presbycusis or ototoxicity from various drugs (49). In rare cases, it can be caused by neurological diseases such as multiple sclerosis, viral infections, auditory nerve tumors, medicines such as quinine and aspirin that have ototoxic potential, and other health problems such as anemia, hyper-/hypothyroidism, hyperinsulinemia, and others (2). Research confirms that mental disorders on the anxiety-depressive spectrum may also contribute to the occurrence of tinnitus (50). Vice versa, people with tinnitus may subsequently develop depressive symptoms and severe social limitations (50). However, the direction of this relationship remains questionable, as it is not clear whether anxiety and depression cause tinnitus or occur consequently. In addition, common causes of tinnitus in young people may be various stress-inducing factors (50).

### Treatment

Despite its widespread presence in the population, the effects of tinnitus treatment are very unsatisfactory, causing great frustration among patients and general practitioners, neurologists, and otolaryngologists alike (51). In most cases, tinnitus is diagnosed based on anamnestic data. In sporadic cases, pulsating tinnitus can be detected by auscultation.

There is currently no registered medication for tinnitus. To date, tinnitus treatment attempts with antidepressants, benzodiazepines, anticonvulsants, glutamate antagonists, counter-vertigo drugs, vitamins, magnesium, and zinc all influenced the comorbidity of tinnitus but had no significant effect on tinnitus itself (52). As it is not possible to eliminate etiological factors for subjective tinnitus, other treatments remain. Sound therapy is performed with either hearing aids (53) or tinnitus-masking sound generators (53). Relaxation therapy for distress or cognitive behavioral therapy are also used (54). Tinnitus retraining therapy is a combination of tinnitus sound therapy and cognitive behavioral therapy that, through



neural modulation, achieves optimal tinnitus habituation, reduces stress, and improves the quality of life with tinnitus (55). Low-frequency magnetic trans-cranial stimulation of the brain has also been applied with the aim of producing weak electrical currents in the brain to reduce neural excitability (56). Attempts have also been made with laser therapy, in most cases without therapeutic effect on tinnitus (57).

When considering surgical interventions, cochlear implantation produces good results in sensorineural hearing impairment, which is often accompanied by tinnitus. Still, in 9% of the treated patients, there is worsening of tinnitus, and in 4% of patients tinnitus occurs even though it did not exist before surgery (58). When compression of the vestibule-cochlear nerve by blood vessels is present, decompression surgical techniques can reduce tinnitus (59). Generally speaking, the effects of these tinnitus therapies are limited, indicating that preventive action on tinnitus risk factors is of primary and paramount public health importance.

## CONCLUSIONS

The prevalence of chronic tinnitus in adolescents is relatively high, but our knowledge of this medical disorder is still insufficient. There are no approved medications for tinnitus, and the results of treatments are disappointing. Therefore, preventing tinnitus in young people should be a public health focus. This review of tinnitus risk factors in young people may be helpful for decision-makers to take urgent countermeasures.

**Author Contributions:** Conceptualization, M.T., G.B., and D.M.; methodology, M.T. and G.B.; writing—first draft, M.T. and G.B.; writing—review and editing, M.T., G.B., L.J.C., D.M., J.I-Z., D.D., A.J. and K.D.; final draft preparation M.T., G.B., L.J.C., D.M., J.I-Z., D.D., A.J. and K.D. All authors have read and approved the final version of the manuscript.

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## FAKTORI RIZIKA I LEČENJE TINITUSA KOD ADOLESCENATA

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### Sažetak

**Uvod:** Tinitus je svesna percepcija zvuka bez spoljašnjeg zvučnog stimulusa. Naziv ovog simptoma potiče od latinske reči tinnire (zvoniti). Zvuk se najčešće percipira kao zujanje, zvonjenje, šištanje, a u manjem broju slučajeva kao glas, muzika ili nekoliko različitih zvukova istovremeno. Tinitus će se kod svakog trećeg čoveka javiti bar jednom u životu, a hronično je prisutan kod 10-15% odraslih. Kod dece i adolescenata, uzrasta od 5 do 19 godina, raspon prevalencije tinitusa je prilično širok (od 5% do preko 40%), u zavisnosti od toga kako je tinitus definisan u studiji. Ovaj rad ima za cilj da pruži najnoviji pregled faktora rizika za nastanak tinitusa i uvid u dosadašnje terapijske pristupe njegovom lečenju kod adolescenata.

**Metode:** Autori su pretraživali baze podataka PubMed, Embase, and Cochrane Review koristeći ključne reči: tinitus, adolescenti, rizično ponašanje, faktori rizika i lečenje. Kriterijum za uključivanje je bio da je članak objavljen na

srpskom ili engleskom jeziku bez zadatih vremenskih okvira.

**Rezultati:** Uobičajeni faktori rizika za tinitus među adolescentima su ženski pol, izloženost buci, gubitak sluha, pušenje marihuane, duvana i izloženost pasivnom pušenju, kao i nedostatak sna. Nedavno su uočeni i dodatni faktori rizika povezani sa navikama u ishrani: nedostatak unosa vode, deficit niacina i proteina i konzumacija zaslađenih gaziranih pića, brze hrane i belog umesto integralnog hleba. Rezultati trenutnog lečenja tinitusa, bilo farmaceutski, hirurški ili bihejvioralni su nezadovoljavajući, što izaziva frustraciju kod pacijenata, ali i lekara. Trenutno ne postoji registrovani lek za tinitus.

**Zaključak:** Tinitus je jedna od najvećih enigmi moderne medicine. S obzirom da se tinitus još uvek smatra neizlečivim, ukazujemo na glavne faktore rizika među adolescentima na koje je značajno usmeriti primarnu prevenciju.

**Ključne reči:** tinitus, adolescenti, rizična ponašanja, faktori rizika i lečenje

**Primljen:** 21.03.2023. | **Revizija:** 30.04.2023. | **Prihvaćen:** 11.06. 2023.

**Medicinska istaživanja 2023; 56(3):27-33**