PREVALENCE AND CHARACTERISTICS OF TINNITUS IN INDIVIDUALS WITH NORMAL HEARING

FREDDY JOSE

19AUD018

This Dissertation is submitted as part fulfilment of

Degree of Master of Science in Audiology

University of Mysore

Mysuru

ALL INDIA INSTITUTE OF SPEECH AND HEARING

Manasagangothri, Mysuru -570 006

September, 2021

CERTIFICATE

This is to certify that this dissertation entitled **'Prevalence and Characteristics of Tinnitus in Individuals with Normal Hearing'** is a bonafide work submitted as a part for the fulfilment for the degree of Master of Science (Audiology) of the student Registration Number: 19AUD018. This has been carried out under the guidance of the faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru

September, 2021

Dr. M. Pushpavathi
Director
All India Institute of Speech and Hearing
Manasagangothri, Mysuru 570 006

CERTIFICATE

This is to certify that this dissertation entitled **'Prevalence and Characteristics of Tinnitus in Individuals with Normal Hearing'** is a bonafide work submitted as a part for the fulfilment for the degree of Master of Science (Audiology) of the student Registration Number: 19AUD018. This has been carried out under my guidance and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru,
September, 2021

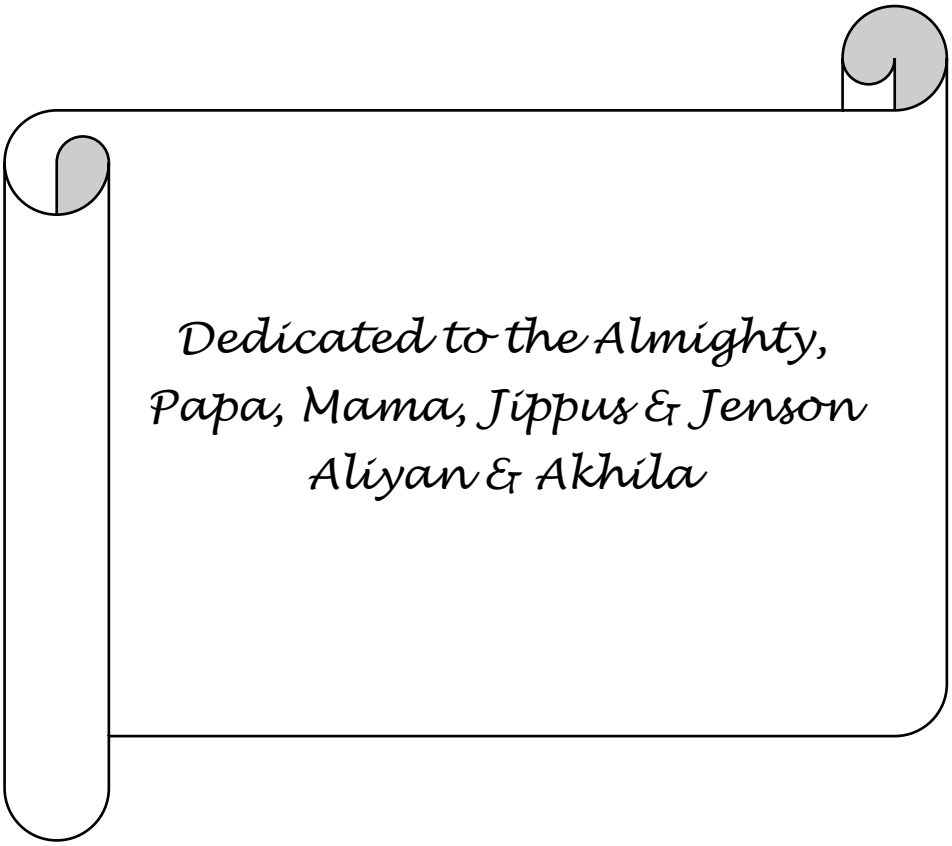
Guide
Dr. Mamatha N.M.
Assistant Professor
Department of Audiology,
All India Institute of Speech and Hearing,
Manasagangothri, Mysuru-570006

DECLARATION

This is to certify that this dissertation entitled **'Prevalence and Characteristics of Tinnitus in Individuals with Normal Hearing'** is the result of my own study under the guidance of Dr. Mamatha N.M., Assistant Professor, Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru, **Registration Number: 19AUD018**

September, 2021


Dedicated to the Almighty,
Papa, Mama, Jippus & Jenson
Aliyan & Akhila

Acknowledgement

Two years of my master's study has come to an end and this dissertation would not have been possible without the help of my family, mentors, teachers and friends. I would like to thank everyone for your support and motivation all along and contributed their excellence helping me achieve my academic ambition.

I am deeply grateful to ***my Papa, mama and sister*** *for their constant encouragement and support at every step in this facet of my life.*

My sincere thanks to ***Dr. M. Puspavathi****, Director, AIISH for permitting me to conduct the study.*

With due respect, I would like to express sincere gratitude to my honourable guide ***Dr. Mamatha N.M.*** *Thank you ma'am for your enduring assistance at every stage of the dissertation. Thank you for your patience and valuable time that you have given me during the dissertation.*

I would like to express my gratitude and appreciation to ***Dr. M S Vasanthalakshmi*** *for giving guidance to complete my statistics work.*

Special thanks to all my classmates for the wonderful days you guys gifted me. My sincere thanks and love to my friends ***Athul, Praveen and Syam.*** *I can't thank you guys enough for the great support and love. And I would like to thank all of my* ***juniors and seniors.***

Finally, I express my heartfelt appreciation to my dissertation partners ***Dilli and Aman*** *for the constant encouragement and support throughout the journey.*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

Tinnitus is the perception of the sound in the absence of an external sound (American Speech and Hearing Association, 2005). Other terms such as ringing in the ears, whistling, pulsing, chirping, roaring etc. have been used to refer to tinnitus. Jasterboff and Hazell (1993) defined tinnitus as the perception of sound in the absence of any stimulation inside the cochlea which is solely resultant of activity inside auditory nervous system. American Speech and Hearing Association (2015) defined tinnitus as the perception of ringing, buzzing or hissing like noise even in the absence of an external sound source and it may be perceived in one or both ears, centered in the head, or localized outside the head.

Tinnitus is found to affect negatively in individuals suffering from it and has been noted that in some individuals, tinnitus is found to cause inability to work, affects cognitive function, sleep disturbance, psychological distress, anxiety, communication problems, depression, tension, irritability, frustration, reduced efficiency and restricted participation in social life (WHO, 2011). The characteristics of tinnitus in both individuals having hearing loss (n = 297) and not having hearing loss (n = 223) were analyzed and it was found that subjective discomfort were higher in patients with hearing loss and characteristics were found to be significantly different among these groups (Savastano, 2008).

Several studies have reported tinnitus as a symptom of any pathological condition that is related to auditory system with or without having any hearing loss. It has also been noted that tinnitus can be related with age, gender, history of ear infection, sinusitis, leisure noise exposure like listening to music at high intensity, alcohol consumption and cigarette smoking (Rhee et al., 2020). Alteration happened

at the level of auditory cortex in those with history of noise exposure can be one of the reason for tinnitus (Rhee et al., 2020).

It has also been noted that, tinnitus occurs due to conditions such as music concerts, gun shooting events, environmental noise, exposure to social/leisure noise such as personal music players, sporting events and events using firecrackers is found to be most relevant for western Europe and North American countries (WHO, 2011). Sometimes certain non-auditory conditions also results in tinnitus (Esmaili & Renton, 2018). Tinnitus is found to be associated with non-auditory conditions like temporomandibular joint dysfunction, diabetes and hypertension (Langguth et al., 2013; Vielsmeier et al., 2012). Tinnitus is also reported to be triggered by usage of certain drugs such as quinine aminoglycoside antibiotics, salicylates, and certain antineoplastic agents, especially the platinum-based drugs (Cianfrone et al., 2011).

The prevalence of tinnitus in United States in 2008 was found to be 29.7 million and out of these 12.95 million people had normal hearing sensitivity, i.e., 44% had no hearing loss and the average age of tinnitus population was 57 year and was found to be more prevalent among individuals aged 55 to 64 year old (Kochkin et al., 2011). In an epidemiological cross sectional survey conducted among 6,571 people representing 25.9 million in Canadian population aged 19 to 79 years, showed that 37% of population had tinnitus and out of this, 7% of this population showed extreme discomfort (Ramage-Morin et al., 2019).

In a Korean cross sectional study, the prevalence of tinnitus between 2009 and 2012 was found to be 20.7% among 19,290 participants in the age range of 20 to 98 years (Kim et al., 2015). The prevalence of tinnitus among normal hearing adolescents aged 12 to 16 years was assessed in South Korea by Rhee et al. (2020) using questionnaire about hearing loss and tinnitus and pure tone audiometry. The

results revealed that among the 1,593 students after excluding conductive hearing loss, 46.0% (i.e., 755 students) were found to have suffered from tinnitus and 9% of them showed some degree of discomfort.

In India, there are very limited studies are available regarding the prevalence of tinnitus. In a door to door survey done to find the prevalence of communication disorders using high risk register in Mandya district of Karnataka state in India shows that 9.6% of total population had tinnitus (Sreeraj et al. 2013). Another Indian study done by Kumaran (2014) also showed that the prevalence of tinnitus in individuals with otological problems was found to be 14.33% (1,766 individuals suffered from tinnitus out of 12,325 cases) based on cases reported to AIISH, Mysore. The results also indicated that among 1,766 tinnitus subjects, 59 (3.3%) were children, 102 (5.8%) were adolescents, 1152 (65.2 %) were adults and 453 (25.7%) were geriatrics. That is, occurrence of tinnitus was found to be more in adults followed by geriatrics, adolescents and children. Of these 17.6% had normal hearing sensitivity and 82.4% had some degree of hearing loss.

1.1 Need for the study

In persons with normal hearing, tinnitus indicates underlying impairment in cochlear or neural functioning at various auditory levels and might suggest a hidden and subclinical otological problem (Kim et al., 2002). Different treatment methods are available for treating individuals with tinnitus such as medical, surgical, palliative, use of tinnitus maskers and hearing aid in presence of hearing loss, electrical stimulation, psychotherapy, relaxation therapy, etc. However, success rate is found to be very less (Makar et al., 2014). Knowledge of the associated factors and comorbidities of tinnitus is important for choosing the appropriate management of individuals suffering from tinnitus (Rhee et al.,2020).

Many studies have shown the prevalence of tinnitus in people with hearing loss, noise exposure, associated conditions like diabetes and hypertension and ototoxicity, while the number of studies showing the prevalence of tinnitus in normal hearing individuals are limited. It is very important to know the prevalence of tinnitus in individuals having normal hearing sensitivity as the results obtained may play an important role in identifying the cause helps in prevention, diagnosis and treatment. Hence, the current study was taken to study the prevalence of tinnitus in individuals having normal hearing sensitivity and to find the cause of the tinnitus if available.

1.2 Aim of the Study

The primary aim of the study was to study the prevalence and characteristics of tinnitus in individuals with normal hearing.

1.3 Objective of the Study

The objectives of the study are as follows:

1. To estimate the prevalence of tinnitus in normal hearing individuals.
2. To estimate the gender predominance in individuals with tinnitus having normal hearing.
3. To estimate the audiological and non audiological characteristics of tinnitus in individuals having normal hearing sensitivity.
4. To analyze the history of tinnitus sufferers and to find the possible causes of tinnitus in individuals with normal hearing.

Chapter 2

REVIEW OF LITERATURE

2.1 Definition and Characteristics of Tinnitus

The term tinnitus is reported to orginate from Latin verb “tinnire” means ‘to ring’ and tinnitus is simply defined as ringing sound heard in one’s own ears. Tinnitus is the abnormal perception of sound due to exclusive activity within the nervous system without any external stimulation and any mechanical and vibratory activity within the cochlea (Jastreboff, 1995). Tinnitus can be continuous, intermittent or pulsatile. Pulsatile tinnitus is found to be in synchronous with heart beat and this could be due to vascular origin and asynchronous type can occur due to myoclonus of the middle ear or palatal muscles (Baguley et al., 2013).

Tinnitus is found to sound like hissing, roaring, whistling, pulsing, etc. and in some individuals with tinnitus, pitch of tinnitus is reported to vary from time to time. Tinnitus is found to occur as unilateral or bilateral or centrally inside the head and sometimes patients reported tinnitus to have an external origin (Baguley et al., 2013). The tinnitus has been broadly classified as subjective and objective type, wherein subjective type refers to tinnitus audible by an individual alone and it is found to arise due to abnormal neural activities not because of external sound source (McCormack et al., 2014). The Objective type of tinnitus is less common type which is audible to external listener and it is found to have caused by sound generated due to internal biological activities (McCormack et al., 2014).

2.2 Various Causes of Tinnitus

The exact cause of tinnitus has been proven to be difficult, however, it has been stated in the literature that most often tinnitus is found to be associated with hearing loss. Also, tinnitus along with hearing loss can be due to various pathological

conditions of the ear, sometimes tinnitus has been reported to be present in normal hearing individuals as well. Tinnitus can occur due to exposure to high level of recreational noise and occupational noise (Baguley et al., 2013). Increased neural activity in the auditory pathway as a compensating mechanism of brain due to decreased sensory input from the cochlea as result of hearing loss can lead to tinnitus (Lugo et al., 2020). Langguth et al. (2013) has found that in individuals with tinnitus having normal hearing are found to have cochlear dead region or damaged outer hair cells. Also subjects with tinnitus having normal hearing thresholds reported to have inner hair cell damage as well (Weisz et al., 2007).

It has been found that those subjects with tinnitus having normal pure tone thresholds are found to have reduced wave I amplitude in auditory brainstem response, which suggests of damage in synapses between hair cell and auditory nerve (Song et al., 2021). Alteration of the auditory nerve such as microvascular compression or vestibular schwannoma is found to result in tinnitus (Langguth et al., 2013). Studies have shown that interaction of amygdala with the auditory pathway as a generation mechanism of tinnitus (Lugo et al., 2020). It is found that pathological changes in the trigeminal system serves as common basis for head ache, migraine and tinnitus and also changes in oscillatory activity called thalamocortical dysrhythmia can also lead to head ache and tinnitus (Lugo et al., 2020). Hyperacusis is seen in 59% of tinnitus population and it is already present in 24% of subgroup before tinnitus begun (Goebel & Floezinger, 2008).

The tinnitus is found to be associated with certain conditions and the various comorbid conditions that are found to be associated with tinnitus are diabetes and hypertension (Langguth et al., 2013; Shargorodsky et al., 2010). Neck injuries and alteration in temporomandibular joint are also found to cause tinnitus sometimes

(Langguth et al., 2013). Sometimes genetic factor are also found to play a role in the occurrence of tinnitus (Kvestad et al., 2010). Tinnitus is found to be more prevalent among individuals having asthma, arthritis, thyroid disease, those with smoking history and sleeping less than six hours (Kim et al., 2015). Other risk factors that are associated with tinnitus includes exposure to loud noise, aging, ototoxicity, anxiety and depression (Choi et al., 2020; Cianfrone et al., 2005; Mckee & Stephens, 2009; Seidman & Jacobson, 1996; Shargorodsky et al., 2010; Yorgason et al., 2006).

2.3 Audiological Characteristics of Tinnitus in Individuals Having Normal Hearing

The distortion product otoacoustic emission and extended high frequency threshold in normal hearing subjects with unilateral tinnitus were assessed and the results indicated abnormal thresholds at extended high frequency audiometry in subjects having conventional normal audiogram (Fabijańska et al., 2012). Evoked emissions were also found to be poor in tinnitus ear with normal hearing and it was also noted that individuals having tinnitus in left ear were found to have poor emission than having tinnitus in right ear (Mckee & Stephens, 2009).

It was also observed that amplitude of DPOAEs were found to be lower in 93% of normal hearing tinnitus group whereas 15% in control group (Shiomi et al., 1997). In a study conducted to evaluate the changes in otoacoustic emission and auditory brainstem response (ABR) in normal hearing subjects with tinnitus as only complaint, reported that 43.8 % subjects had absent DPOAE and latency of wave I in ABR was found to be significantly prolonged than control group (Dadoo et al., 2019).

In subjects with tinnitus, pitch matching is found to have consistently occurred at frequencies where they are noted to have hearing loss (Norena et al., 2002) or at edge frequency between normal or near normal and where hearing loss starts (Moore

et al., 2010). This can be because of over representation of adjacent frequencies in cortical area due to damage of some cochlear region (Moore et al., 2010).

2.4 Epidemiology of Tinnitus

The characteristics of tinnitus in subjects with and without hearing loss was examined and results showed that prevalence of tinnitus in normal hearing subjects was found to be 7.4% out of 744 subjects and tinnitus was found to be more predominant in females and constant pattern of tinnitus is more found to be more frequent than intermittent pattern, although these results were not statistically significant (Sanchez et al., 2005). In a review done in tinnitus in children, prevalence of tinnitus in normal hearing children was found to be 12% to 36% and 66% in children with hearing impairment (Shetye & Kennedy, 2010). In a survey done in Korea the prevalence of tinnitus was assessed using questionnaires and results indicated that among 19,290 participants aged 20 to 98 year old, 20.7% of subjects had tinnitus and also prevalence was found to increase the with age (Kim et al., 2015).

The prevalance of tinnitus was assessed in 3,669 participants aged 20 to 69 year old asian americans using questionnaires on tinnitus. The results of the study indicated prevalence of 6.6% which is significantly less than whites, blacks and Hispanics and major significant risk factor for tinnitus among asian americans were found to be noise exposure and depression (Choi et al., 2020).

In another study done in Sweden found the prevalence and characteristics of tinnitus, from the city of Gothenburg (425,000 inhabitants), in a random sample consisting of 3600 subjects in the age range of 20 to 80 year old inhabitants using questionnaires. The results indicated that 66% of them responded and 14% of them reported to have tinnitus more often. Tinnitus was found to be more common among males than in females. In unilateral cases, the tinnitus is found to be more common in

left ear than in the right ear. Also tinnitus is found to be more common in individuals having hearing loss than in normal hearing individuals (Axelsson & Ringdahl, 1989).

In Indian context number of studies showing the prevalence ot tinnitus are limited. In a door to door survey done using high risk register in 15,441 individuals to find the prevalence of communication disorders in randomly selected 15 villages of Mandya district of Karnataka state in India. Their study results showed that 9.6% of total population had tinnitus. It is also found that tinnitus is more prevalent among females than males and in the age range of 15 to 50 years (Konadath et al., 2013).

Another Indian study done by Kumaran (2014) in his master's thesis done at AIISH, Mysore showed that the prevalence of tinnitus in individuals with otological problems was found to be 14.33% (1,766 individuals suffered from tinnitus out of 12,325 cases) based on cases reported to AIISH, Mysore between July 2012 and June 2013. The results also indicated that among 1,766 tinnitus subjects, 59 (3.3%) were children, 102 (5.8%) were adolescents, 1152 (65.2 %) were adults and 453 (25.7%) were geriatrics. That is, occurrence of tinnitus was found to be more in adults followed by geriatrics, adolescents and children. Of these 17.6% had normal hearing sensitivity and 82.4% had some degree of hearing loss.

Based on review of literature, prevalence of tinnitus among normal hearing population is less compared to population having hearing loss. In Indian context, the study done on prevalence and characteristics of tinnitus in individuals with normal hearing is very less. However, information related to the prevalence and characteristics of tinnitus in individuals with normal hearing can assist in better prevention and management.

Chapter 3

METHODS

The current study was conducted at All India Institute of Speech and Hearing (AIISH), Mysore, with the aim of finding the prevalence and characteristics of tinnitus in normal hearing individuals. A retrospective case analysis was performed by reviewing the case files of individuals who visited institute presenting with the complaints related to ear and/or hearing from January 2019 to December 2019.

3.1 Participants

The Clinical Database Management Application (CDMA) software and Microsoft Excel based application register were used to find the total number of individuals who visited the outpatient department (OPD) of Audiology and presenting with the complaint of tinnitus and diagnosed as having hearing sensitivity within normal limits (≤ 25 dB HL). From the clinical service registration section, the following details from the case files were obtained:

- Demographic data (age & gender)
- Primary and secondary complaints such as ear pain, ear discharge, blocking sensation, itching sensation along with tinnitus.
- Laterality of the tinnitus (unilateral or bilateral)
- Pattern of tinnitus such as continuous, intermittent or pulsatile
- Medical history and significant risk factors like hypertension, diabetes, hypothyroidism, giddiness, head trauma, noise exposure etc.
- Audiological test results such as Transient Evoked Otoacoustic Emission, Distortion Product Otoacoustic Emission, Tinnitus Matching (frequency &

intensity), residual inhibition and Auditory Brainstem Response (site of lesion) if available.

3.2 Following Inclusion and Exclusion Criteria Were Considered for Selection of Participants

Inclusion Criteria

- Subjects of any age with reported complaint of tinnitus.
- Subjects who have undergone pure tone audiometry and having pure tone average less than or equal to 25 dB HL in both ears.
- Subjects who have undergone tympanometry having 'A' type tympanogram and present/absent acoustic reflexes.

Exclusion Criteria

- Subjects with PTA > 25 dB HL in one or both ears.
- Subjects with tympanogram patterns such as 'As, 'Ad', 'B', 'C', 'Cs' and 'Cd'
- Subjects diagnosed as having conductive, sensorineural and mixed hearing loss.
- Subjects with neurological and psychological problems.

3.3. Procedures

3.3.1. Pure Tone Audiometry

In the department of Audiology, standard audiometric test procedures and testing conditions were followed for evaluating hearing abilities. Pure tone and speech audiometry, immittance evaluation and transient/distortion product otoacoustic emission testing were carried out in sound treated double room situation (ANSI, 1999). The standard procedures included obtaining pure tone thresholds using modified Hughson and Westlake procedure (Carhart, & Jerger, 1959) in the

audiometric test frequencies from 250 to 8000 Hz for air-conduction and 250 to 4000 Hz for bone- conduction. The normal degree of hearing based on World Health Organization Classification were considered for the study. The subjects with pure tone average (PTA) ≤ 25 dB classified as having hearing sensitivity within normal limits and classification of hearing threshold calculated by taking average of pure tone threshold obtained at 500Hz, 1000Hz, 2000Hz & 4000Hz.

3.3.2. Tympanometry

The assessment of tympanometry was done using 226 Hz probe tone. A tympanogram was classified as A-type when the tympanometric peak pressure was within -100 to +60 daPa, and the static admittance was within 0.5 to 1.75 mmho; As-type when the tympanometric peak pressure was within -100 to +60 daPa, and the static admittance was less than 0.5 mmho; B-type when the tympanogram was flat, and the compliance could not be stabilized; Ad-type when the tympanometric peak pressure was between -100 to +60 daPa, and the static admittance was more than 1.75 mmho and C-type when the tympanometric peak pressure was less than -100 daPa; Cs-type when the tympanometric peak pressure was less than -100 daPa, and the static admittance was less than 0.05 mmho and Cd-type when tympanometric peak pressure was less than -100 daPa, and static admittance was more than 1.75 mmho (Feldman, 1976; Lidén et al., 1974)

3.3.3 Otoacoustic Emissions (OAEs)

The results of Transient Evoked OAE testing that was done in a sound proof room for click stimulus at 80- 85dBPeSPL (Kemp, 1978) in the frequencies of 1000Hz, 1500Hz, 2000Hz, 3000Hz and 4000Hz and Distortion Product OAE testing was done with pure tone stimulus of intensity L1 (65dBSPL) and L2 (55 dB SPL) and in frequencies of 1000Hz, 1500Hz, 2000Hz, 3000Hz, 4000Hz and 6000Hz with a

stimulus frequency ratio of 1.22 was noted. Overall SNR level of 6 dB or above was considered as the presence of OAEs at least at the consecutive three frequencies tested (Norton et al., 2000). For every case initially, TEAOE was done; if TEAOE was absent, then only DPOAE was measured.

3.3.4 Auditory Brainstem Response - Site of lesion

Auditory Brainstem Response - Site of lesion (ABR- SOL) testing was carried out using clicks stimuli at low and high repetition rates. Latency of I, III and V peak was mentioned in the case file. Based on the latency values, ABR-SOL was considered to be positive (indication of RCP) if the interpeak latency difference (IPLD) was more than 2 ms, or if no identifiable V peak was present at a high repetition rate, or if the interaural difference (IALD) of V peak latency was $\geq$ 0.4 ms.

The interpretation and diagnosis of these audiological tests that were made by the experience and certified clinical audiologist in AIISH was noted and considered for analysis.

3.4 Statistical Analysis

The collected case details from the case files were systematically segregated and tabulated in Microsoft Excel and Statistical Package for the Social Sciences (SPSS) version 25 and descriptive analysis was carried out. The data was analyzed to find the prevalence and characteristics of tinnitus in individuals having normal hearing across different age group such as children, adolescents, adults and geriatrics and across gender. Statistical analysis had done to find the various risk factors (hypertension, diabetes, hypothyroidism, giddiness, head trauma, noise exposure etc) associated with tinnitus. The results of audiological tests (TEOAE, DPOAE & Tinnitus Matching, residual inhibition, ABR - SOL) were also analysed. Pearson Chi-square test was done to see if there was any significant association across age and

gender with various risk factors associated with tinnitus in individuals having normal hearing.

Chapter 4

RESULTS

The aim of the current study was to determine the prevalence and characteristics of tinnitus in normal hearing individuals who reported to Audiology OPD, All India Institute of Speech and Hearing (AIISH), Mysuru, from January 2019 to December 2019. A register-based retrospective study was carried out by reviewing total of 16,368 clients had visited AIISH. The Client Database Management Software revealed that out of these, 13,780 subjects had undergone audiological evaluation. The collected case details from the case files were systematically segregated and tabulated in Microsoft Excel and Statistical Package for the Social Sciences (SPSS) version 25 for analysis of the collected data.

4.1 Prevalence of Tinnitus in Individuals Having Normal Hearing

Among the total 13,780 subjects who had undergone audiological evaluation, 2,465 individuals were diagnosed as having normal hearing sensitivity (i.e., PTA ≤ 25dBHL). Out of these 2,465 subjects, 517 subjects satisfied the inclusion criteria of the present study. Hence, the prevalence of the tinnitus in individuals with normal hearing who visited department of Audiology at All India Institute of Speech and Hearing in the year 2019 is 21%. Out of these 517 subjects, 224 individuals reported tinnitus as a primary complaint. Remaining subjects had multiple complaints like ear pain, itching, blocking sensation and history of ear discharge along with tinnitus.

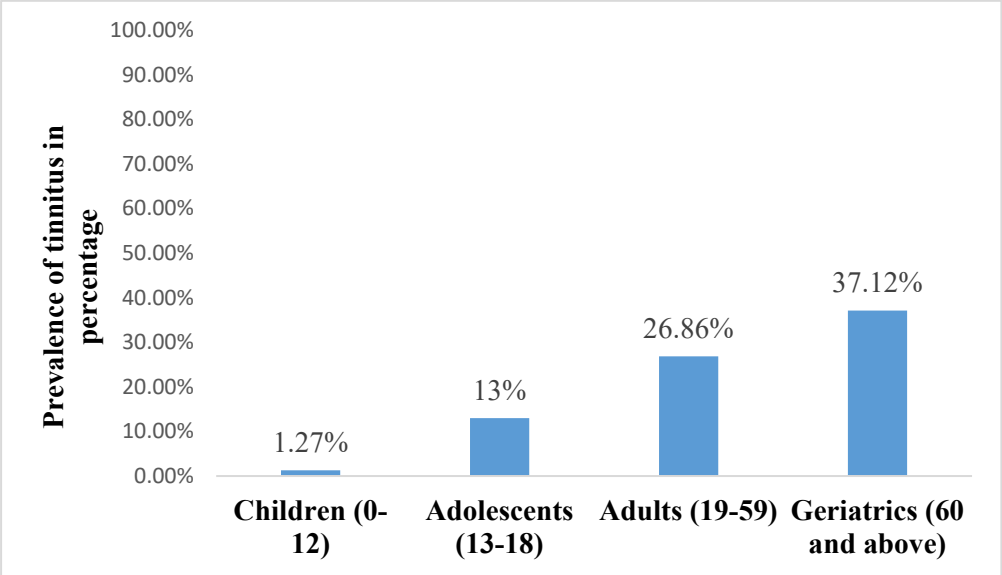
4.1.1 Tinnitus in Individuals Having Normal Hearing in Different Age Groups

To assess age wise prevalence of tinnitus in individuals having normal hearing, subjects were divided into four different age groups: 0 – 12 years (children), 13 – 18 years (adolescent years), 19 – 59 years (adult) and 60 & above (geriatrics). The total number of individuals who visited department of Audiology at AIISH

having normal hearing are 549, 184, 1530 and 202 in children, adolescent, adult and geriatrics respectively. Out of these 7 children, 24 adolescents, 411 adult and 75 geriatrics had tinnitus with normal hearing. The prevalence of tinnitus in four different age group is presented in figure 4.1.

Figure 4.1

Prevalence of tinnitus across different age groups (in years)



From Figure 4.1 it can be noted that, prevalence of tinnitus in the present study are 1.27% among children, 13% in adolescent, 26.86% in adults and 37.12% among geriatrics. That is, prevalence of tinnitus in individuals having normal hearing is high among the geriatrics followed by adults, adolescent and children who visited Audiology clinic, AIISH.

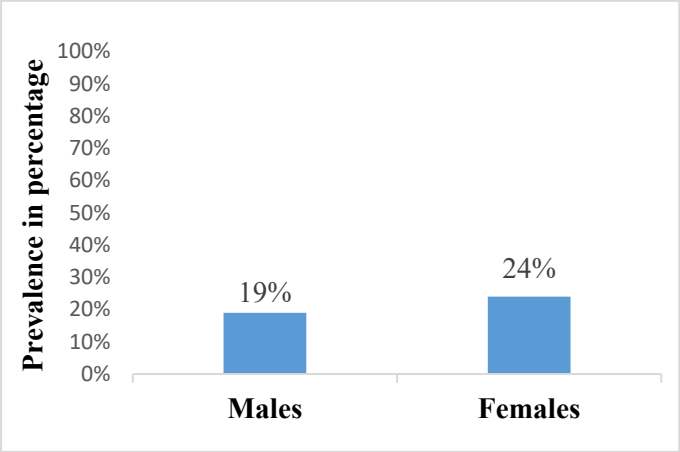
4.1.2 Tinnitus in Individuals Having Normal Hearing across Gender

Among the 2,465 individuals who visited AIISH audio clinic and diagnosed as having normal hearing, 1379 were males and 1086 were females. Out of these 517 subjects who had tinnitus with normal hearing, 260 were males and 257 were females. Hence, the prevalence of tinnitus in individuals having normal hearing who visited

Audiology clinic in males and females are 19% and 24% respectively. The prevalence of tinnitus in normal hearing males and female subjects is given in Figure 4.2. From the Figure 4.2 it is evident that, prevalence of tinnitus individuals having normal hearing is higher in females than males.

Figure 4.2

Prevalence of tinnitus in normal hearing males and females

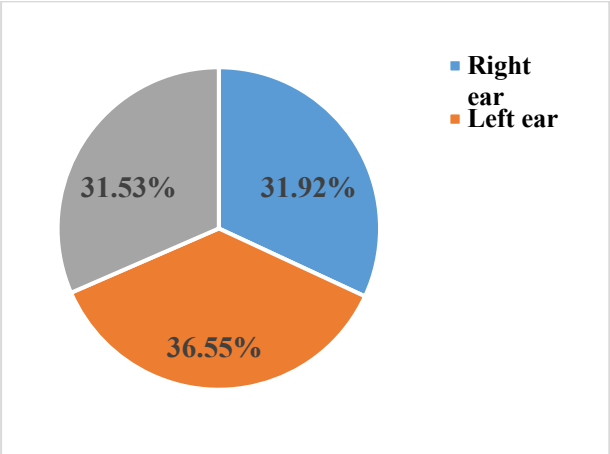


4.2. Analysis of Unilateral V/S Bilateral Tinnitus in Individuals Having Normal Hearing

Out of 517 tinnitus subjects having normal hearing, 354 subjects had unilateral tinnitus (68.47%) and 163 had bilateral tinnitus (31.53%). Out of 354 individuals having unilateral tinnitus, 165 subjects had tinnitus in right ear (31.92%) and 189 subjects had tinnitus in left ear (36.55%). The percentage of unilateral and bilateral tinnitus in individuals having normal hearing are given in Figure 4.3. From figure 4.3 it can be observed that, occurrence of unilateral tinnitus is more than bilateral tinnitus and occurrence of unilateral tinnitus in left ear is more compared to right ear.

Figure 4.3

Percentage of unilateral and bilateral tinnitus in normal hearing subjects

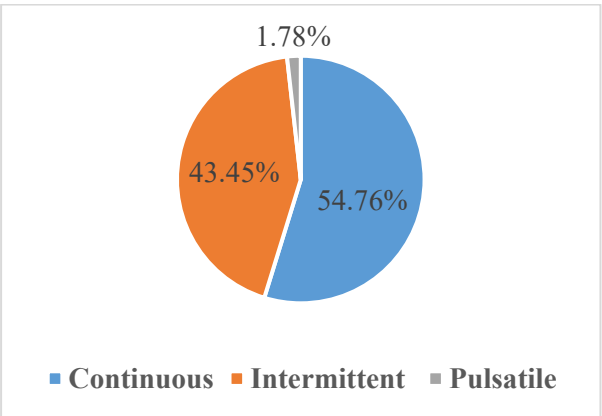


4.3 Pattern of Tinnitus in Individuals Having Normal Hearing

Out of 517 normal hearing subjects having tinnitus, pattern of tinnitus was specified in 168 subjects. Out of 168 subjects, 92 (54.76%), 73 (43.45%) and 3 (1.78%) individuals had reported continuous, intermittent and pulsatile pattern of tinnitus respectively and the same results are given in Figure 4.4.

Figure 4.4

Pattern of tinnitus reported in tinnitus subjects with normal hearing



From figure 4.4 it can be noted that continuous pattern of tinnitus was more prevalent followed by intermittent and pulsatile pattern in subjects with tinnitus having normal

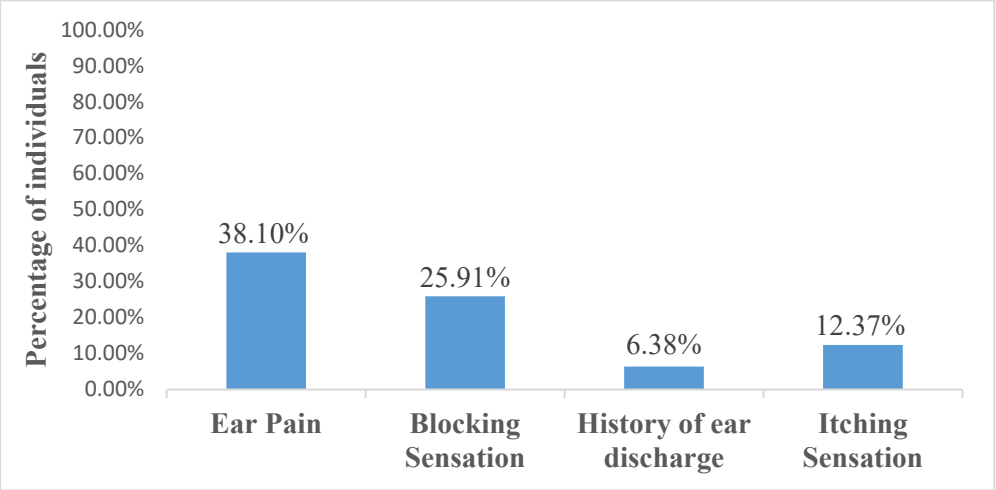
hearing. Pearson Chi-square test was done to if there exists an association between pattern of tinnitus and other complaints such as ear pain, blocking sensation, itching sensation and history of ear discharge. The results indicated that there is no significant association found between pattern of tinnitus and other complaints: ear pain [χ^2 (2) = 2.408, p=0.300*)*; history of ear discharge[χ^2 (2) = 0.268, p =0.875]; blocking sensation [χ^2 (2) = 1.406, p =0.495] and itching sensation [χ^2 (2) = 0.892, p =0.640] and risk factors associated with tinnitus like noise exposure [χ^2 (2) = 4.514, p =0.105]; head trauma [χ^2 (2) = .701, p =0.704]; hypertension [χ^2 (2) = 1.208, p =0.547]; diabetes [χ^2 (2) = .772, p =0.680]; frequent cold [χ^2 (2) = .412, p =0.814]; hypothyroidism [χ^2 (2) = .640, p =0.726]; giddiness[χ^2 (2) = 3.841, p =0.147] and head ache [χ^2 (2) = 2.748, p =0.253].

4.4 Analysis of Other Complaints among Tinnitus Subjects Having Normal Hearing

Out of 517 tinnitus subjects having normal hearing, 224 individuals reported tinnitus as the primary and only complaint. The remaining 293 tinnitus subjects were presented with multiple combinations of complaints such as ear pain, blocking sensation, itching sensation and history of ear discharge and the results are provided in figure 4.5.

Figure 4.5:

Percentage of individuals having other complaints along with tinnitus



From figure 4.5 it is evident that, out of 517 subjects having tinnitus, 197 (38.1%) had ear pain 134 (25.91%) had blocking sensation 33 (6.38%) had history of ear discharge and 64 (12.37%) had itching sensation. In order to see if there exists an association between age and each of the other complaints in tinnitus subjects having normal hearing Pearson Chi-square test was done. The results indicated that there was a significant association between age and complaint of ear pain [χ^2 (3) = 9.931, p =0.19]. Ear pain was found to be more in children followed by adolescent, adult and geriatrics.

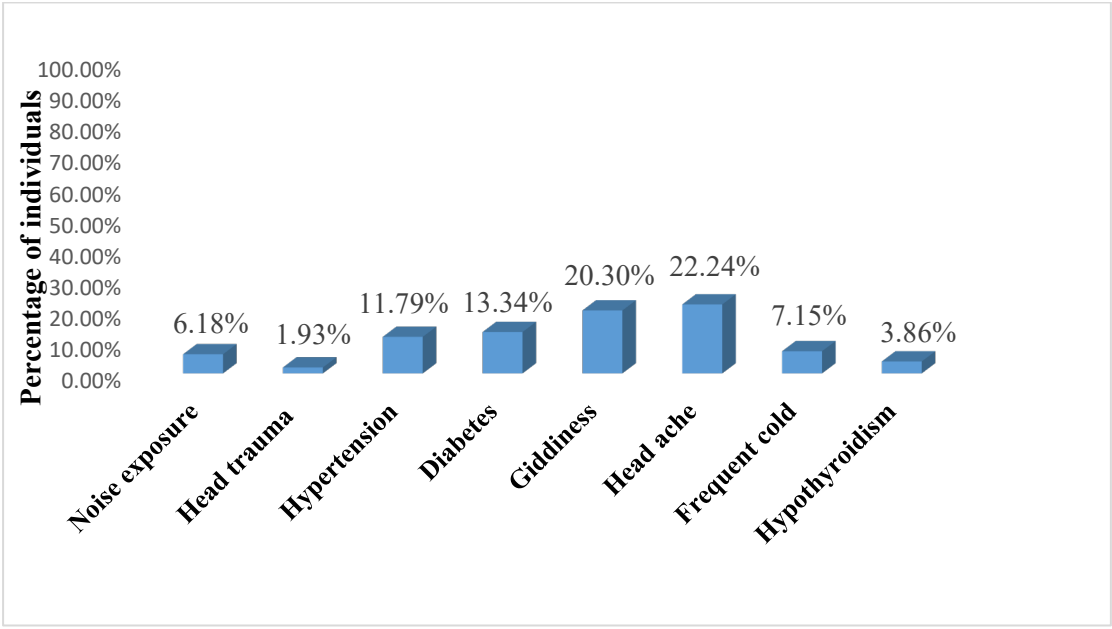
But no significant association was found between blocking sensation [χ^2 (3) = 1.056, p =0.788], history of ear discharge [χ^2 (3) = 3.992, p =0.262] and itching [χ^2 (3) = 1.116, p =0.773]. Significant association was found between gender and ear pain [χ^2 (1) = 4.781, p =0.029]. Frequency distribution shows 42.8% females and 33.5% males had ear pain. No significant association was found between gender and ear discharge [χ^2 (1) = .255, p =0.613], blocking sensation [χ^2 (1) = .463, p =0.496] and itching [χ^2 (1) = 1.250, p =0.264].

4.5 Analysis of risk factors associated with tinnitus in normal hearing subjects

The risk factors that were associated with tinnitus subjects (n=517) having normal hearing were analyzed. The results of frequency distribution analysis of risk factors associated with tinnitus that were present in the 517 normal hearing tinnitus subjects are given figure 4.6.

Figure 4.6

Percentage of individuals with various associated risk factors.



From figure 4.6 it can be observed that 32 subjects had history of noise exposure (6.18%), 10 subjects had head trauma (1.93%), 61 had hypertension (11.79%), 69 had diabetes (13.34%), 105 had giddiness (20.3%), 115 had head ache (22.24%), 37 had frequent cold (7.15%) and 20 had hypothyroidism (3.86%). Pearson Chi-square test was done to see an association between age and each of the associated factors (given in figure 4.5) in tinnitus subjects. The results indicated that there was a significant association found between age and noise exposure [χ^2 (3) = 8.798, p =0.032]. Noise exposure was found only across adult subjects. Significant association

was found between age and hypertension [χ^2 (3) = 32.377, p =0.000]; age and diabetes [χ^2 (3) = 29.383, p =0.000]; age and giddiness [χ^2 (3) = 14.093, p =0.003]. Analysis of frequency distribution reveals that more number of Geriatrics subjects was found to have hypertension and diabetes compared to adults. Giddiness was found to be more in Geriatrics followed by adults and adolescents. No significant association was found between age and head trauma [χ^2 (3) = 2.414, p =0.491], age and headache [χ^2 (3) = .596, p =0.897], age and frequent cold [χ^2 (3) = 4.884, p =0.180], age and hypothyroidism [χ^2 (3) = 3.173, p =0.366].

Significant association was found between gender and noise exposure [χ^2 (1) = 29.612, p =0.000]. Analysis of frequency distribution reveals that 11.9% male had noise exposure and only 0.4% female had noise exposure. Significant association was found between gender and head ache [χ^2 (1) = 19.417, p =0.000]. Head ache was present in 30.4% of females and 14.2% of males. No significant association was found between gender and head trauma [χ^2 (1) = .000, p =0.985], gender and giddiness [χ^2 (1) = .376, p =0.540], gender and hypertension [χ^2 (1) = .034, p =0.854], diabetes [χ^2 (1) = 1.237, p =0.266], gender and frequent cold [χ^2 (1) = 3.661, p =0.056] and gender and hypothyroidism [χ^2 (1) = 3.426, p =0.064].

4.6 Analysis of Results of Otoacoustic Emissions in subjects with Tinnitus having Normal Hearing

The results of Transient Evoked Otoacoustic Emission (TEOAE) & Distortion Product Otoacoustic Emission (DPOAE) obtained for subjects with both unilateral and bilateral tinnitus having normal hearing were analyzed and results are given in table 4.1 and table 4.2 respectively.

From table 4.1 it can be noted that Transient Evoked Otoacoustic Emission (TEOAE) test was done in 191 out of 354 unilateral tinnitus subjects. Out of 191

unilateral tinnitus subjects, TEOAE was found to be absent at 111 (58.11%) subjects. Out of 163 subjects having bilateral tinnitus TEOAE was done in 93 subjects (186 ears). Out of 186 ears, TEOAE was absent in 108 ears (58.06%). Hence, overall TEOAE was found to be absent in 58.09% of tinnitus ears having normal hearing sensitivity.

Table 4.1

TEOAE & DPOAE in Unilateral and Bilateral Subjects.

TEOAE			
Unilateral Tinnitus (191 ears)		Bilateral Tinnitus (186 ears)	
Present	Absent	Present	Absent
80 (41.89%)	111(58.11%)	78 (41.94%)	108(58.06%)
DPOAE			
Unilateral Tinnitus (111 ears with absent TEOAE)		Bilateral Tinnitus (108 ears with absent TEOAE)	
Present	Absent	Present	Absent
40 (36%)	71 (64%)	43 (39.81%)	65 (60.19%)

From table 4.1 it can be noted that TEOAE test was done in 191 out of 354 unilateral tinnitus subjects. Out of 191 unilateral tinnitus subjects, TEOAE was found to be absent at 111 (58.11%) subjects. Out of 163 subjects having bilateral tinnitus TEOAE was done in 93 subjects (186 ears). Out of 186 ears, TEOAE was absent in 108 ears (58.06%). Hence, overall TEOAE was found to be absent in 58.09% of tinnitus ears having normal hearing sensitivity.

From table 4.1 it can be observed that DPOAE test was done in 111 ears with absent TEOAE in unilateral tinnitus subjects and 108 ears with bilateral tinnitus in bilateral tinnitus subjects. Out of 111 ears of unilateral tinnitus subjects with absent

TEOAE, 40 ears (36%) had DPOAE present and 71 ears (64%) had DPOAE absent. That means, both TEOAE and DPOAE were absent in 64% of unilateral subjects**.** Out of 108 ears of bilateral subjects with absent TEOAE, 43 ears (39.81%) had DPOAE present and 65 ears (60.19%) had DPOAE absent. That is, 60.19% ears of bilateral cases had both TEOAE and DPOAE absent. So overall both TEOAE and DPOAE was absent in 62.1% of tinnitus ears.

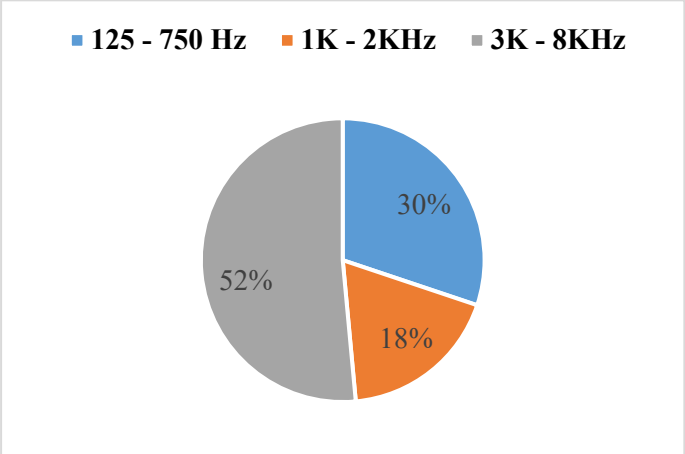
4.7 Analysis of Tinnitus Matching in Tinnitus Subjects Having Normal Hearing

4.7.1 Frequency Matching

Tinnitus matching was performed in 136 ears. The percentage of tinnitus subjects matching their tinnitus with different frequency is analyzed and are given in Figure 4.7.1. From the figure 4.7.1, it can be observed that out of 136 ears, 41 ears (30%) matched their tinnitus with frequencies from 125 Hz to 750 Hz (125 Hz, 250 Hz, 500 Hz & 750 Hz), 25 ears (18%) matched their tinnitus with frequencies from 1000 Hz to 2000 Hz (1000 Hz, 1500 Hz & 2000 Hz) and 70 ears (52%) matched their tinnitus with frequencies from 3000Hz to 8000Hz (3000 Hz, 4000 Hz, 6000 Hz & 8000 Hz). From these findings it can be concluded that more number of subjects matched their tinnitus to high frequency, i.e., between 3000 Hz to 8000 Hz followed by individuals matching to lower frequencies (125-750 Hz). It was also evident that less number of individuals matched their tinnitus to mid frequencies, i.e., between 1000Hz and 2000Hz.

Figure 4.7.1

Frequency Matched with Tinnitus

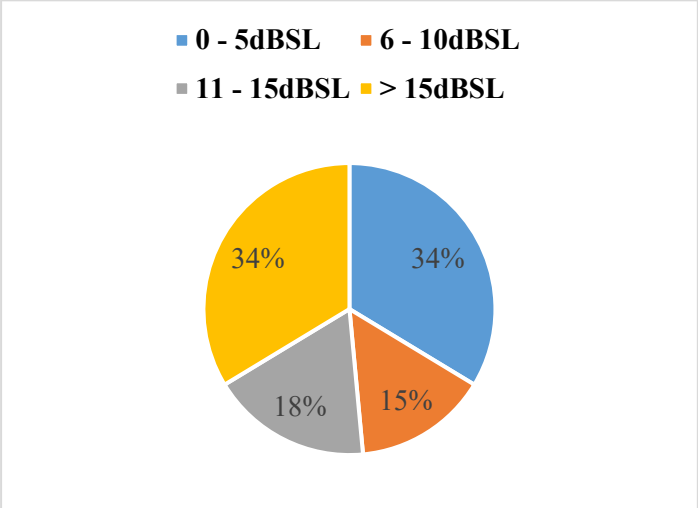


4.7.2 Loudness Matching

Tinnitus matching was performed in 136 ears. The percentage of tinnitus subjects matching their tinnitus loudness with different intensity level is analyzed and are given in Figure 4.7.2. From figure 4.7.2, it can be observed that out of 136 ears, 46 ears (34%) matched their tinnitus loudness with 0 to 5 dB SL, 20 (15%) matched their tinnitus loudness with 6 to 10 dB SL, 24 ears (18%) matched their tinnitus loudness with 11 to 15 dB SL and 46 ears (34%) matched their tinnitus loudness to >15 dB SL. From the figure 4.7.2, it can be concluded that more number of subjects with tinnitus matched their tinnitus loudness to 0-5 dBSL and > 15 dBSL. Less number of subjects with tinnitus matched their tinnitus loudness to 6-10 dB SL and 11-15 dB SL.

Figure 4.7.2

Loudness Matched with Tinnitus

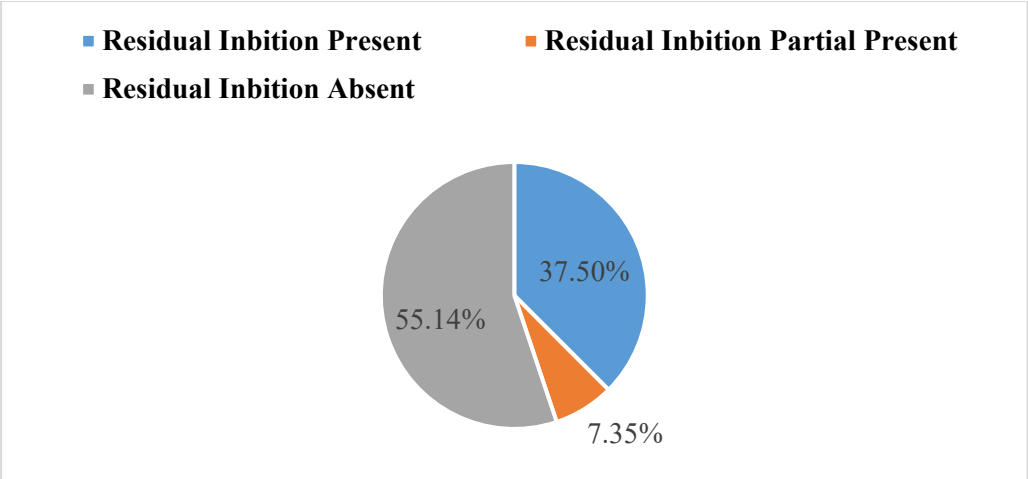


4.7.3 Residual Inhibition

Out of 136 ears, residual inhibition was present in 51 ears (37.5 %), partially present in 10 ears (7.35 %) and absent in 75 ears (55.14 %). That is residual inhibition is completely present only in 37.5 % of normal hearing tinnitus subjects.

Figure 4.7.3

Residual Inhibition in Tinnitus Subjects



4.8. Analysis of Auditory Brainstem Response (Site of lesion) in Subjects with Tinnitus Having Normal Hearing

Among 517 subjects with tinnitus having normal hearing (354 unilateral &163 bilateral tinnitus), 14 subjects (8 unilateral & 6 bilateral subjects) were diagnosed as having retrocochlear pathology. In individuals with bilateral tinnitus retrocochlear pathology was present in both the ears. A total of 2.70 % of the total normal hearing subjects with tinnitus had retrocochlear pathology.

4.9 Analysis of Vestibular assessment done in subjects with tinnitus having normal hearing

Out of 517 subjects having tinnitus, 15 subjects were found to have vestibular dysfunction (2.90%). Out of these 15 subjects, 5 were diagnosed as having Meniere's disease, 4 as Benign Paroxysmal Positional Vertigo, 4 as Vestibular Migraine and 2 as Vestibular Neuritis respectively. Hence, vestibular involvement was present in few of the subjects with tinnitus having normal hearing considered in the study.

Chapter 5

DISCUSSION

The present study was conducted with the aim to find the prevalence and characteristics of tinnitus in individuals having normal hearing who visited department of Audiology of AIISH between January, 2019 and December, 2019. The results obtained are discussed under the following heading.

5.1 Prevalence of Tinnitus in Individuals with Normal Hearing

The prevalence of tinnitus in individuals with normal hearing in the present study was found to be 21%. The prevalence obtained in present study is higher than that was reported by Konadath et al. 2013, who reported prevalence of tinnitus as 9.6% in general population. The reason for the difference could be that the earlier study had reported the prevalence of tinnitus in general population where as in the present study, prevalence of tinnitus is taken only from subjects diagnosed as having normal hearing who had visited department of Audiology in AIISH in the year 2019. Higher prevalence obtained in the current study could be because people visit AIISH from different part of the country and hence having greater representation of individuals from different geographical area.

5.2 Tinnitus in Normal Hearing Individuals in Different Age Groups

In the present study, tinnitus was found to be more prevalent among geriatrics followed by adults, adolescents and children. These results are in agreement with the findings of Kim et al., (2015) and Xu et al., (2011) who has reported that prevalence of tinnitus increases with the age. The reasons for increased prevalence of tinnitus among geriatrics could be due to age related factors like degeneration of cells and neurons and other associated conditions like hypertension and diabetes among geriatric population. Less prevalence of tinnitus among children could be attributed to

the reason that children may consider tinnitus as an usual event and rarely complain of tinnitus which is supported by Savastano et al., (2009) who has found that the total percentage of children with tinnitus rises from 6.5% to 34% when children are specifically questioned about having tinnitus in their ears.

5.3 Tinnitus in Normal Hearing Individuals across Gender

In the present study, the prevalence of tinnitus among females (24%) were found to be more than males (19%). It is supported by the study done in general population by Kim et al., (2015); Konadath et al., (2013); Mahboubi et al., (2013) and Rhee et al., (2020), who reported high prevalence among females. Mahboubi et al., (2013) reported prevalence of tinnitus in youth population in United States to be 43% in males and 57% in females. Rhee et al., (2020) reported prevalence among adolescents in South Korea to be 39% in males and 54% in females.

In contrary to current study few authors have reported prevalence of tinnitus to be more among males (Amir. B et al.,2011 & Stouffer & Tyler, 1990). The discrepancies found between studies could be due to difference in amount of stress, noise exposure and various other etiological factors associated with tinnitus across gender in different geographical area.

5.4 Analysis of Laterality of Tinnitus in Individuals having Normal Hearing

In the current study, subjects with unilateral tinnitus (68.47%) is twice as that of bilateral cases (31.53%). This is in disagreement with the study done by Sanchez et al., (2005) and Stouffer & Tyler, (1990), where they reported prevalence of bilateral tinnitus to be more compared to unilateral.

Also in the current study, it is found that in subjects with unilateral tinnitus, left ear tinnitus is more compared to right ear, which is in agreement with the findings

by the Axelsson & Ringdahl, (1989) and Stouffer & Tyler, (1990), who also reported occurrence of tinnitus in left ear to be more.

5.5 Pattern of Tinnitus in Individuals Having Normal Hearing

The present study results reveal that continuous tinnitus is more frequent than intermittent and pulsatile pattern of tinnitus. Very few studies have mentioned the pattern of tinnitus in their studies. Langguth et al. (2013) reported that non pulsatile tinnitus is more frequent than the pulsatile tinnitus and it is also reported that continuous tinnitus is usually associated with conductive or sensorineural component. This could be the reason for more frequent continuous pattern of tinnitus followed by intermittent and pulsatile pattern of tinnitus. Also different pathophysiological changes of individual subjects would have resulted in different pattern of tinnitus.

5.6 Analysis of Other Complaints among Tinnitus Subjects Having Normal Hearing

Analysis of other complaints such as ear pain, blocking sensation, history of ear discharge and itching sensation in normal hearing subjects with tinnitus reveals that ear pain is more frequently reported than other complaints. The reason could be that ear pain related to conductive component or any discomfort in ear may be perceived as pain especially in case of children. Chi square analysis reveals that the occurrence of ear pain is also associated with age. It can also be attributed to greater chance of occurrence of conductive pathology in children due to incomplete maturation of the external and middle ear. The number of subjects with history of ear discharge were less in the current study could be because of cessation of perception of tinnitus in most of the resolved conductive cases and also subjects with active ear discharge were excluded from the study due to ‘B’- type tympanogram.

5.7 Analysis of Risk Factors Associated with Tinnitus in Normal Hearing Subjects

Analysis of risk factors reveals that head ache is found to be more frequently associated with tinnitus in normal hearing subjects. This in agreement with the study conducted by Langguth et al., (2017), where it was found out that tinnitus subjects with comorbid head ache had higher scores in tinnitus questionnaires compared to tinnitus subjects without having comorbid head ache. Rather than a risk factor, head ache could be a symptom associated with tinnitus and this could also be a reason for head ache as most frequent factor associated with tinnitus. The headache symptom is followed by giddiness, diabetes, hypertension, frequent cold, noise exposure, hypothyroidism and head trauma.

Study done by Gopinath et al., (2010); H. J. Kim et al., (2015); Langguth et al., (2013); Martines et al., (2015) support the present study findings. Risk factors for occurrence of tinnitus has been supported many authors: Gopinath et al., (2010) supports giddiness as major factor of tinnitus; Kim et al. (2015) support the risk factors such as noise exposure and thyroid disease; Langguth et al., (2013) supports risk factors such as noise exposure, diabetes and hypertension; Martines et al., (2015) supports risk factors such as diabetes, hypertension and head ache.

Also proximity of the vestibular system and cochlea can be one of the reason for the giddiness as a major risk factor as explained by Gopinath et al., (2010). Changes in the blood flow in subjects with hypertension which can affect the functioning of the inner ear could be a reason for tinnitus among these subjects (Shargorodsky et al., 2010). Also changes in auditory neuroplasticity can be attributed to reason for tinnitus among subjects with history of noise exposure and without noticeable hearing loss (Rhee et al., 2020).

5.8 Analysis of Results of Otoacoustic Emissions (OAE) in Normal Hearing Tinnitus Subjects

Transient evoked OAE was found to be absent in 58% of the tinnitus ears in the present study which is supported by Thabet (2009) who has reported that among the normal hearing tinnitus subjects, TEOAE was found to be abnormal in 85% of the subjects. In the present study DPOAE was done in subjects with absent TEOAE (58%) and DPOAE was found to be absent in 62% of the subjects. Decrease in DPOAE amplitude was observed in 93% of normal hearing tinnitus subjects over a limited frequency range has been indicated by Shiomi et al., (1997). Whereas Dadoo et al., (2019) reported absent DPOAE in 43.8% subjects which supports current study findings. Discrepancies in the percentage of abnormal OAEs among the various studies could be due to difference in number of participants considered in the study and other various cochlear physiological mechanisms.

5.9 Analysis of Tinnitus Matching

In the current study, it was seen that more number of subjects matched their tinnitus to higher frequencies followed by lower frequencies and later by mid frequencies. It could be due to higher possibility of having hearing loss at high frequencies than lower and mid frequencies. As in the current study even though normal hearing subjects were considered, few of the subjects had hearing loss at high frequencies such as 6000Hz and 8000Hz, where in these frequencies pure tone threshold is not considered for taking pure tone average. The findings of current study is supported by Moore et al., (2010) who has reported occurrence of tinnitus at edge frequency between frequency having normal threshold and in frequency where hearing loss starts and hence justifies the frequent occurrence of tinnitus at high frequency.

Frequency distribution of loudness matching reveals that more number of subjects matched loudness to 0 – 5 dBSL and > 15dBSL. The loudness of tinnitus found to be varying from individual to individual and depends on the number of nerve fibers activated and rate of temporal activity (Erlandsson et al., 1992). Also unknown various pathophysiological changes occurring in the auditory system would have resulted in perception of tinnitus at various loudness levels.

Residual Inhibition is found to be absent for 55% of ears, partially present in 7% of ears and completely present in 38% of the ears. These results are supported by Dessai et al., (2014) who has found that among 10 normal hearing participants with tinnitus, 3 had complete termination following residual inhibition therapy, 4 had reduction in loudness and 3 had no change. The difference obtained between the studies could be due number of individuals considered in the study, method adopted, causes of tinnitus and various unknown pathophysiological changes.

5.10 Analysis of Auditory Brainstem Response - Site of lesion

Results of current study reveals that 14 out of 517 (2.7 %) subjects had retrocochlear pathology. These findings are supported by Langguth et al., (2013) who has stated that alteration of the auditory nerve such as microvascular compression or vestibular schwannoma can result in tinnitus. However, in the current study cause for the retro cochlear disorder was not known.

5.11 Analysis of Vestibular Assessment Done in Normal Hearing Tinnitus Subjects

Results of the current study reveals that out of 517 subjects, 5 were diagnosed as having Meniere's disease, 4 had Benign Paroxysmal Positional Vertigo (BPPV), 4 had Vestibular Migraine and 2 had Vestibular Neuritis. As tinnitus is one of the major symptoms in individuals having Meniere's disease and fluctuating nature of hearing

loss and tinnitus in early stage of Meniere's disease could be the reason for having tinnitus. In support of current study, Coelho et al., (2020) found that 19% of individuals having BPPV and 46% to 68% of vestibular migraine subjects had tinnitus.

Chapter: 6

SUMMARY AND CONCLUSIONS

The current study was carried out at All India Institute of Speech and Hearing (AIISH), Mysore, with the aim of finding the prevalence and characteristics of tinnitus in normal hearing individuals. A retrospective case analysis was performed by reviewing the case files of individuals who were diagnosed as having normal hearing (PTA ≤ 25dBHL) and tinnitus as one of the presenting complaint from January 2019 to December 2019.

The details regarding the presence of tinnitus in normal hearing individuals, the primary and secondary complaints such as ear pain, ear discharge, blocking sensation, itching sensation along with tinnitus, laterality of the tinnitus (unilateral or bilateral), pattern of tinnitus such as continuous, intermittent or pulsatile were noted and analysed. The medical history and significant risk factors like hypertension, diabetes, hypothyroidism, giddiness, head trauma, noise exposure and audiological test results such as Transient Evoked Otoacoustic Emission, Distortion Product Otoacoustic Emission, Tinnitus Matching (frequency & intensity), residual inhibition and Auditory Brainstem Response (Site of lesion) were collected and analysed further.

The results obtained from the current study revealed that:

The prevalence of tinnitus in normal hearing individuals was 21% in individuals who have reported to Department of Audiology at All India Institute of Speech and Hearing between the period from January 2019 and December 2019. The analysis of prevalence of tinnitus in individuals having normal hearing across age reveals that geriatrics had high prevalence (37.12%) followed by adults (26.86%), adolescents (13%) and children (1.27%). The analysis of prevalence of tinnitus across

gender revealed that females (24%) are more prone to tinnitus compared to males (19%).

Among the subjects considered, 68.47% had unilateral and 31.53% had bilateral tinnitus. In unilateral tinnitus subjects, 31.92% had tinnitus in right ear and 36.55% had tinnitus in left ear. Among the pattern of tinnitus specified, continuous pattern (54.76%) of tinnitus is found to be more frequent than intermittent (43.45%) and pulsatile tinnitus (1.78%). In addition, it was found that more subjects with tinnitus had ear pain (38%), especially in children followed by blocking sensation (26%), itching sensation (12%) and history of ear discharge (6%). Among the risk factors, head ache (22%) was found to more frequent followed by giddiness (20%), diabetes (13%), hypertension (12%), frequent cold (7%), noise exposure (6%), hypothyroidism (4%) and head trauma (2%).

TEOAE was found to be absent in 58% of tinnitus ears having normal hearing sensitivity. DPOAE was found to be absent in 62% of tinnitus ears with absent TEOAE's. Most of the subjects who had done tinnitus matching, matched their tinnitus to higher frequencies followed by lower frequencies and later by mid frequencies. Frequency distribution of loudness matching reveals that more number of subjects matched their tinnitus loudness to 0 – 5 dBSL and > 15dBSL. Further, residual Inhibition is found to be absent for 55% of ears, partially present in 7% of ears and present in 38% of ears.

Results of auditory brainstem site of lesion test results reveals that 2.7 % normal hearing subjects with tinnitus had retrocochlear pathology. Vestibular assessment done in these subjects reveals that out of 517 subjects, 5 had Meniere's disease, 4 had Benign Paroxysmal Positional Vertigo (BPPV), 4 had Vestibular Migraine and 2 had Vestibular Neuritis.

Implications of the Study

- The current study throws light on the prevalence of tinnitus in individuals with normal hearing.
- Information related to various risk factors and characteristics of tinnitus will help for identification of causes and consequences of the tinnitus.
- The information about prevalence and characteristics of tinnitus in normal hearing individuals helps in planning the awareness programs about causes, prevention, early identification, diagnosis and intervention programs for individuals with tinnitus having normal hearing.

REFERENCES

Axelsson, A., & Ringdahl, A. (1989). Tinnitus--a study of its prevalence and characteristics. British Journal of Audiology, 23(1), 53–62. https://doi.org/10.3109/03005368909077819

Baigi, A., Oden, A., Almlid-Larsen, V., Barrenäs, M. L., & Holgers, K. M. (2011). Tinnitus in the general population with a focus on noise and stress: a public healthstudy.*Earandhearing*, *32*(6),787-789. https://doi.org/10.1097/AUD.0b013e31822229bd

Baguley, D., McFerran, D., & Hall, D. (2013). Tinnitus. *The Lancet*, *382*(9904), 1600–1607. https://doi.org/10.1016/S0140-6736(13)60142-7

Choi, J. S., Yu, A. J., Voelker, C. C. J., Doherty, J. K., Oghalai, J. S., & Fisher, L. M. (2020). Prevalence of Tinnitus and Associated Factors Among Asian Americans: Results From a National Sample. *Laryngoscope*, *130*(12), E933–E940. https://doi.org/10.1002/lary.28535

Cianfrone, G., Pace, M., Turchetta, R., Cianfrone, F., & Altissimi, G. (2005). An updated guide on drugs inducing ototoxicity, tinnitus and vertigo. *Acta otorhinolaryngologica Italica: organo ufficiale della Societa italiana di otorinolaringologia e chirurgia cervico-facciale*, *25*(5 Suppl 81), 3-31.

Cianfrone, G., Pentangelo, D., Cianfrone, F., Mazzei, F., Turchetta, R., Orlando, M. P., & Altissimi, G. (2011). Pharmacological drugs inducing ototoxicity, vestibular symptoms and tinnitus: A reasoned and updated guide. In *European Review for Medical and Pharmacological Sciences* (Vol. 15, Issue 6, pp. 601–636).

Coelho, C. B., Santos, R., Campara, F., & Tyler, R. (2020). *Classification of Tinnitus Multiple Causes with the Same Name*. https://doi.org/10.1016/j.otc.2020.03.015

Dadoo, S., Sharma, R., & Sharma, V. (2019). Oto-acoustic emissions and brainstem evoked response audiometry in patients of tinnitus with normal hearing. *International Tinnitus Journal*, *23*(1), 18–25. https://doi.org/10.5935/0946-5448.20190004

Dessai, T. D., Gopinath, R., Krishnan, L., & Susan, G. (2014). Effectiveness of residual inhibition therapy. *International Tinnitus Journal*, *19*(1), 63–67. https://doi.org/10.5935/0946-5448.20140009

Erlandsson, S. I., Hallberg, L. R. M., & Axelsson, A. (1992). Psychological and audiological correlates of perceived tinnitus severity. *International Journal of Audiology*, *31*(3), 168–179. https://doi.org/10.3109/00206099209072912

Esmaili, Aa., & Renton, J. (2018). 206 CLINICAL A REVIEW OF TINNITUS. *Australian Journal of General Practice*, *47*(4), 205–208.

Fabijańska, A., Smurzyński, J., Hatzopoulos, S., Kochanek, K., Bartnik, G., Raj-Koziak, D., Mazzoli, M., Skarżynski, P. H., Jędrzejczak, W. W., Szkiełkowska, A., & Skarżyński, H. (2012). The relationship between distortion product otoacoustic emissions and extended high-frequency audiometry in tinnitus patients. Part 1: Normally hearing patients with unilateral tinnitus. *Medical Science Monitor : International Medical Journal of Experimental and Clinical Research*, *18*(12), CR765. https://doi.org/10.12659/MSM.883606

Feldman, A. S. (1976). Tympanometry: application and interpretation. *Annals of Otology, Rhinology and Laryngology*, *85*(Sup.25), 202–208. https://doi.org/10.1177/00034894760850s238

Goebel, G., & Floezinger, U. (2008). Pilot study to evaluate psychiatric co-morbidity in tinnitus patients with and without hyperacusis. *Audiological Medicine*, *6*(1), 78–84. https://doi.org/10.1080/16513860801959100

Gopinath, B., McMahon, C. M., Rochtchina, E., Karpa, M. J., & Mitchell, P. (2010). Risk Factors and Impacts of Incident Tinnitus in Older Adults. *Annals of Epidemiology*, *20*(2), 129–135. https://doi.org/10.1016/j.annepidem.2009.09.002

Jastreboff, P. J., & Hazell, J. W. P. (1993). A neurophysiological approach to tinnitus: Clinical implications. *British Journal of Audiology*, *27*(1), 7–17. https://doi.org/10.3109/03005369309077884

Kemp, D. T. (1978). Stimulated acoustic emissions from within the human auditory system. *Journal of the Acoustical Society of America*, *64*(5), 1386–1391.

https://doi.org/10.1121/1.382104

Kim, H.-J., Lee, H.-J., An, S.-Y., Sim, S., Park, B., Kim, S. W., Lee, J. S., Hong, S. K., & Choi, H. G. (2015). Analysis of the Prevalence and Associated Risk Factors of Tinnitus in Adults. *PLOS ONE*, *10*(5), e0127578. https://doi.org/10.1371/JOURNAL.PONE.0127578

Kim, H. J., Lee, H. J., An, S. Y., Sim, S., Park, B., Kim, S. W., Lee, J. S., Hong, S. K., & Choi, H. G. (2015). Analysis of the prevalence and associated risk factors of Tinnitus in adults. *PLoS ONE*, *10*(5), 1–15. https://doi.org/10.1371/journal.pone.0127578

Kim, S. H., Frisina, D. R., & Frisina, R. D. (2002). Effects of age on contralateral suppression of distortion product otoacoustic emissions in human listeners with normal hearing. *Audiology and Neuro-Otology*, *7*(6), 348–357. https://doi.org/10.1159/000066159

Kochkin, S., Tyler, R., & Born, J. (2011). MarkeTrak VIII: The prevalence of tinnitus in the United States and the self-reported efficacy of various treatments. *Hearing Review*, *18*(12), 10–27.

Konadath, S., Suma, C., Jayaram, G., Sandeep, M., Mahima, G., & Shreyank, S. (2013). Prevalence of Communication Disorders in a Rural Population of India. *La Aparición De Trastornos De Comunicación Entre La Población Rural En La India.*, *3*(2), 41–49.

Kumaran T, Geetha C (2014). One year prevalance and risk factors of tinnitus in individuals with otological problems (Unpublished master's thesis). AIISH, Mysuru, Karnataka

Kvestad, E., Czajkowski, N., Engdahl, B., Hoffman, H. J., & Tambs, K. (2010). Low Heritability of Tinnitus: Results From the Second Nord-Trøndelag Health Study. *Archives of Otolaryngology–Head & Neck Surgery*, *136*(2), 178–182. https://doi.org/10.1001/ARCHOTO.2009.220

Langguth, B., Hund, V., Landgrebe, M., & Schecklmann, M. (2017). Tinnitus patients with comorbid headaches: The influence of headache type and laterality on tinnitus characteristics. *Frontiers in Neurology*, *8*(AUG), 440.

https://doi.org/10.3389/fneur.2017.00440

Langguth, B., Kreuzer, P. M., Kleinjung, T., & De Ridder, D. (2013). Tinnitus: Causes and clinical management. In *The Lancet Neurology* (Vol. 12, Issue 9, pp. 920–930). Lancet Neurol. https://doi.org/10.1016/S1474-4422(13)70160-1

Lidén, G., Harford, E., & Hallén, O. (1974). Automatic tympanometry in clinical practice. *International Journal of Audiology*, *13*(2), 126–139. https://doi.org/10.3109/00206097409071671

Lugo, A., edvall, N. K., Lazar, A., Mehraei, G., Lopez-escamez, J.-A. A., Bulla, J., Uhlen, I., Canlon, B., Gallus, S., cederroth, C. R., & edvall, N. K. (2020). Relationship between headaches and tinnitus in a Swedish study. *Scientific Reports*, *10*(1), 1–12. https://doi.org/10.1038/s41598-020-65395-1

Mahboubi, H., Oliaei, S., Kiumehr, S., Dwabe, S., & Djalilian, H. R. (2013). The prevalence and characteristics of tinnitus in the youth population of the United States. *Laryngoscope*, *123*(8), 2001–2008. https://doi.org/10.1002/lary.24015

Makar, S. K., Biswas, A., & Shatapathy, P. (2014). The Impact of Tinnitus on Sufferers in Indian Population. *Indian Journal of Otolaryngology and Head and Neck Surgery*, *66*(SUPPL.1), 37–51. https://doi.org/10.1007/s12070-011-0291-x

Martines, F., Sireci, F., Cannizzaro, E., Costanzo, R., Martines, E., Mucia, M., Plescia, F., & Salvago, P. (2015). Clinical observations and risk factors for tinnitus in a Sicilian cohort. *European Archives of Oto-Rhino-Laryngology*, *272*(10), 2719–2729. https://doi.org/10.1007/s00405-014-3275-0

McCormack, A., Edmondson-Jones, M., Fortnum, H., Dawes, P., Middleton, H., Munro, K. J., & Moore, D. R. (2014). The prevalence of tinnitus and the relationship with neuroticism in a middle-aged UK population. *Journal of Psychosomatic Research*, *76*(1), 56–60. https://doi.org/10.1016/j.jpsychores.2013.08.018

Mckee, G. J., & Stephens, S. D. G. (2009). *An Investigation of Normally Hearing Subjects with Tinnitus*. https://doi.org/10.3109/00206099209072919

Moore, B. C. J., Vinay, & Sandhya. (2010). The relationship between tinnitus pitch

and the edge frequency of the audiogram in individuals with hearing impairment and tonal tinnitus. *Hearing Research*, *261*(1–2), 51–56. https://doi.org/10.1016/J.HEARES.2010.01.003

Norena, A., Micheyl, C., Chéry-Croze, S., & Collet, L. (2002). Psychoacoustic Characterization of the Tinnitus Spectrum: Implications for the Underlying Mechanisms of Tinnitus. *Audiology and Neurotology*, *7*(6), 358–369. https://doi.org/10.1159/000066156

Norton, S. J., Gorga, M. P., Widen, J. E., Folsom, R. C., Sininger, Y., Cone-Wesson, B., Vohr, B. R., Mascher, K., & Fletcher, K. (2000). Identification of Neonatal Hearing Impairment: Evaluation of transient evoked otoacoustic emission, distortion product otoacoustic emission, and auditory brain stem response test performance. *Ear and Hearing*, *21*(5), 508–528. https://doi.org/10.1097/00003446-200010000-00013

Ramage-Morin, P. L., Banks, R., Pineault, D., & Atrach, M. (2019). Tinnitus in Canada. *Health Reports*, *30*(3), 4–11. https://doi.org/10.25318/82-003-x201900300001-eng

Rhee, J., Lee, D., Suh, M. W., Lee, J. H., Hong, Y. C., Oh, S. H., & Park, M. K. (2020). Prevalence, associated factors, and comorbidities of tinnitus in adolescents. *PLoS ONE*, *15*(7 July). https://doi.org/10.1371/journal.pone.0236723

Sanchez, T. G., de Medeiros, Í. R. T., Levy, C. P. D., da Rosa Oiticica Ramalho, J., & Bento, R. F. (2005). Tinnitus in normally hearing patients: clinical aspects and repercussions. *Brazilian Journal of Otorhinolaryngology*, *71*(4), 427–431. https://doi.org/10.1016/s1808-8694(15)31194-0

Savastano, M. (2008). Tinnitus with or without hearing loss: Are its characteristics different? *European Archives of Oto-Rhino-Laryngology*, *265*(11), 1295–1300. https://doi.org/10.1007/s00405-008-0630-z

Savastano, M., Marioni, G., & de Filippis, C. (2009). Tinnitus in children without hearing impairment. *International Journal of Pediatric Otorhinolaryngology*, *73*(SUPPL.1), S13–S15. https://doi.org/10.1016/S0165-5876(09)70003-5

Seidman, M. D., & Jacobson, G. P. (1996). Update on tinnitus. In *Otolaryngologic Clinics of North America* (Vol. 29, Issue 3, pp. 455–465). https://doi.org/10.1016/s0030-6665(20)30367-4

Shargorodsky, J., Curhan, G. C., & Farwell, W. R. (2010). Prevalence and characteristics of tinnitus among US adults. *American Journal of Medicine*, *123*(8), 711–718. https://doi.org/10.1016/j.amjmed.2010.02.015

Shetye, A., & Kennedy, V. (2010). Tinnitus in children: An uncommon symptom? In *Archives of Disease in Childhood* (Vol. 95, Issue 8, pp. 645–648). BMJ Publishing Group. https://doi.org/10.1136/adc.2009.168252

Shiomi, Y., Tsuji, J., Naito, Y., Fujiki, N., & Yamamoto, N. (1997). Characteristics of DPOAE audiogram in tinnitus patients. *Hearing Research*, *108*(1–2), 83–88. https://doi.org/10.1016/S0378-5955(97)00043-9

Song, Z., Wu, Y., Tang, D., Lu, X., Qiao, L., Wang, J., & Li, H. (2021). Tinnitus Is Associated With Extended High-frequency Hearing Loss and Hidden High-frequency Damage in Young Patients. *Otology & Neurotology : Official Publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology*, *42*(3), 377–383. https://doi.org/10.1097/MAO.0000000000002983

Stouffer, J. L., & Tyler, R. S. (1990). Characterization of tinnitus by tinnitus patients. *Journal of Speech and Hearing Disorders*, *55*(3), 439–453. https://doi.org/10.1044/jshd.5503.439

Thabet, E. M. (2009). Evaluation of tinnitus patients with normal hearing sensitivity using TEOAEs and TEN test. *Auris Nasus Larynx*, *36*(6), 633–636. https://doi.org/10.1016/j.anl.2009.01.002

Vielsmeier, V., Strutz, J., Kleinjung, T., Schecklmann, M., Kreuzer, P. M., Landgrebe, M., & Langguth, B. (2012). Temporomandibular joint disorder complaints in Tinnitus: Further hints for a putative Tinnitus subtype. *PLoS ONE*, *7*(6), e38887. https://doi.org/10.1371/journal.pone.0038887

Weisz, N., Müller, S., Schlee, W., Dohrmann, K., Hartmann, T., & Elbert, T. (2007). The Neural Code of Auditory Phantom Perception. *Journal of Neuroscience*,

27(6), 1479–1484. https://doi.org/10.1523/JNEUROSCI.3711-06.2007

WHO. (2011). *Burden of disease from environmental noise: Quantification of healthy life years lost in Europe*.

Xu, X., Bu, X., Zhou, L., Xing, G., Liu, C., & Wang, D. (2020). An Epidemiologic Study of Tinnitus in a Population in Jiangsu Province, China. *Journal of the American Academy of Audiology*, *22*(09), 578–585. https://doi.org/10.3766/JAAA.22.9.3

Yorgason, J. G., Fayad, J. N., & Kalinec, F. (2006). Understanding drug ototoxicity: molecular insights for prevention and clinical management. *Http://Dx.Doi.Org/10.1517/14740338.5.3.383*, *5*(3), 383–399. https://doi.org/10.1517/14740338.5.3.383