Perceived Tinnitus Severity in Normal-Hearing Tinnitus Subjects

Background

Most experts agree that the tinnitus signal is generated at least in part by discordant damage of outer hair cells (OHCs). Discordant damage refers to the phenomenon that OHCs are more susceptible to damage than their adjacent inner hair cells (IHCs). OHCs and IHCs provide input to the dorsal cochlear nucleus (DCN). Discordant damage creates imbalanced input to the DCN, resulting in abnormal high-frequency bursts of nerve activity within the DCN which then propagate throughout the auditory nervous system. These abnormal high-frequency bursts then are perceived by the auditory cortex as sound: tinnitus.

OHC damage can be great enough to result in measurable hearing loss; in such cases, reduced sound input causes the auditory neural network to enhance the strength of the aberrant high-frequency signals which are finally perceived by the auditory cortex as a sound: tinnitus. However, OHC damage can be so slight that it cannot be detected by routine hearing tests and yet generate the tinnitus signal. In fact, the cochlea can sustain diffuse damage to up to 30% of the OHCs before hearing loss is measurable (Bohne & Clark,1982; Chen & Fechter, 2003). Approximately 20% of tinnitus patients have normal hearing (Davis & El Refaie, 2000).

Benton (2010) reported significant differences in hearing thresholds between groups of tinnitus and non-tinnitus subjects; tinnitus subjects demonstrated better hearing than non-tinnitus subjects, a finding attributed to the significant difference ($p < .001$) in the mean age of the two groups: the tinnitus subjects (n=644) were significantly younger (55.96 years, SD 12.45) than the non-tinnitus subjects (n = 1889, mean 66.09 years, SD 13.27). Not surprisingly, hearing

aid use was more common among non-tinnitus subjects (58.9%) than among tinnitus subjects (41.1%).

Benton's (2010) data also revealed that 45% of the tinnitus subjects had normal hearing as defined by threhsolds of 25 dB HL or better at all octave frequencies 250-8000 Hz and at 3000 and 6000 Hz. Figure 1 presents the percentage of Tinnitus and Non-Tinnitus subjects demonstrating varying degrees of hearing loss using the binaural four-frequency average (1, 2, 3 & 4 kHz) calculated using common weighting: [(5 x poorer ear) + (better ear)] / 6.

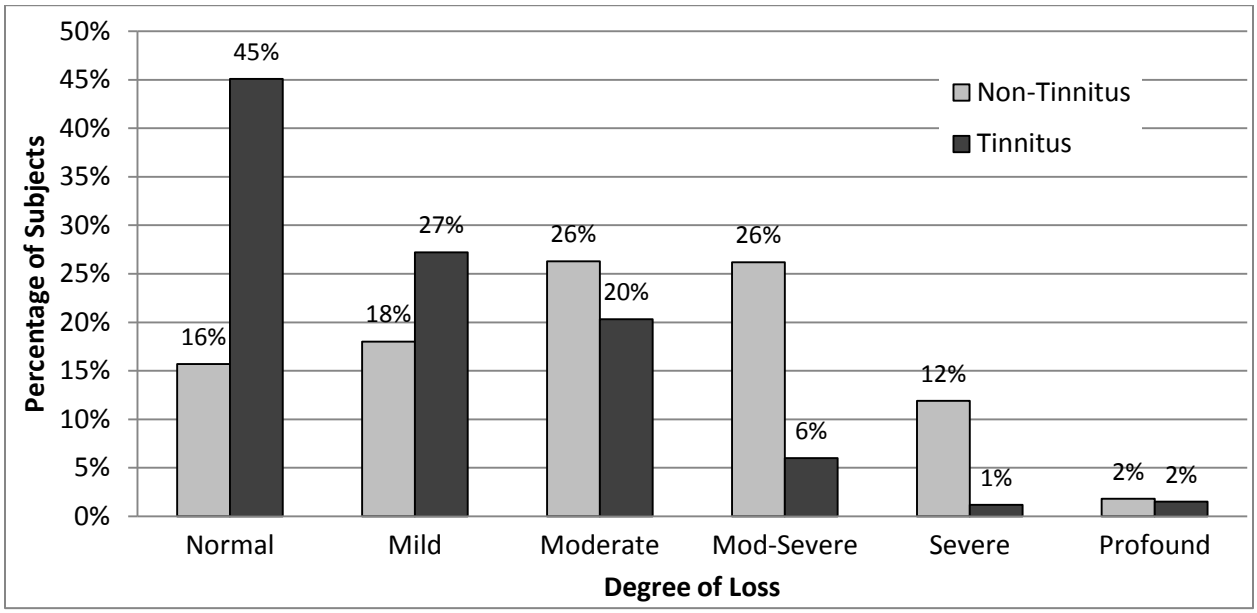

Figure 1. A comparison of the percentage of Tinnitus and Non-Tinnitus subjects demonstrating various degrees of hearing loss (based on four-frequency averages of 1000, 2000, 3000 and 4000 Hz).

Audiologists have long been aware that tinnitus patients who demonstrate normal hearing thresholds frequently report substantial tinnitus-related distress. We were interested in exploring these issues to obtain a greater understanding of normal-hearing tinnitus patients.

We identified 109 normal-hearing subjects who had sought tinnitus services at the VA Medical Center in Atlanta in a 6-month period. Their mean hearing thresholds are shown in **Figure 1** and their mean acoustic-reflex and speech-audiometry values are shown in **Table 1**. The mean age of these normal-hearing tinnitus subjects was 43.85 years (SD = 11.02).

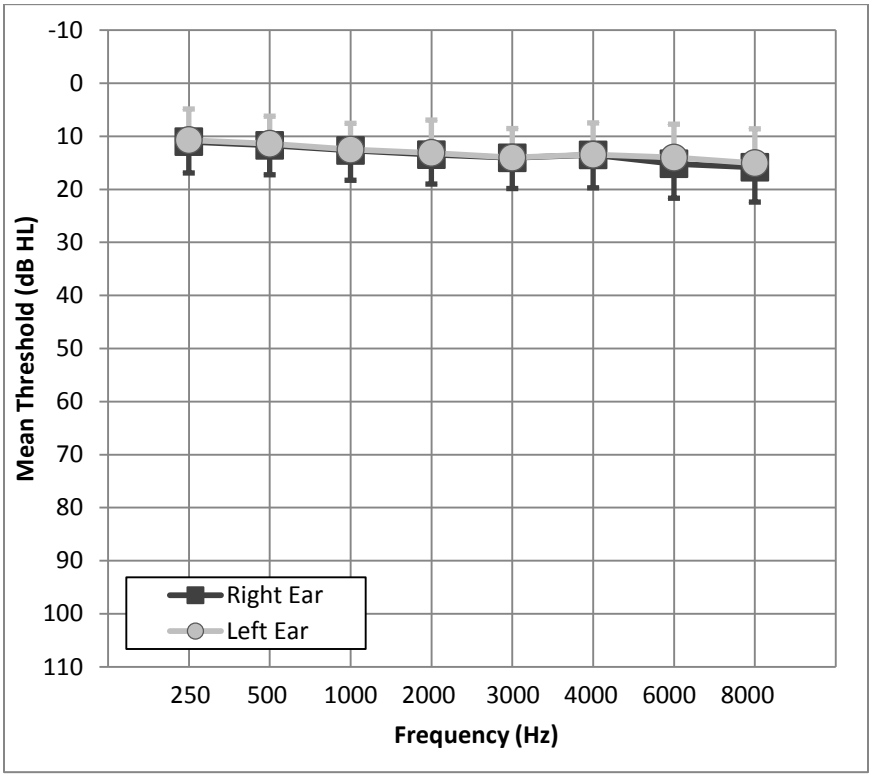

Figure 1. Mean hearing thresholds for 109 normal-hearing tinnitus subjects

	Right Ear		Left Ear	
Mean 1kHz Reflex Thresholds (SD)	Contra	Ipsi	Contra	Ipsi
	83.41 (7.30)	80.68 (5.83)	84.09 (5.49)	81.82 (5.68)
Mean Speech Audiometry Values (SD)	SRT	WRS %	SRT	WRS %
	9.63 (4.12)	94.50 (6.86)	9.17 (4.52)	94.00 (9.21)

Table 1. Mean 1kHz reflex thresholds and speech audiometry values for 109 normal-hearing tinnitus subjects.

The majority of subjects (n=93, or 82%) reported being aware of their tinnitus at least 50% of waking hours, and 57 subjects (50%) reported being aware of their tinnitus 100% of waking hours. Ringing was the most common tinnitus description (n=95, or 83%) and the majority of subjects experienced bilateral tinnitus (n=96, or 84%).

Mental health (MH) disorders were highly prevalent among this group of normal-hearing tinnitus subjects: 84 subjects (74%) had at least one diagnosed MH disorder, and 52 of these subjects (62%) had two or more diagnosed MH disorders. **Table 2** presents the most commonly occurring specific MH diagnoses identified in this group of subjects.

Most Commonly Occurring Mental Health Diagnoses	
Post-Traumatic Stress Disorder (PTSD) Only	20 (24%)
Depression Only	17 (20%)
PTSD + Depression	20 (24%)
PTSD + Depression + Anxiety	7 (8%)
Depression + Other	10 (12%)
Other Diagnos(es)	10 (12%)

Table 2. The most commonly occurring mental health diagnoses in a group of 84 normal-hearing tinnitus patients diagnosed with at least one mental health disorder.

Measures of Perceived Tinnitus Severity and Tinnitus-Related Distress

Various measures of perceived tinnitus severity and tinnitus-related distress were available in this group of subjects. According to McCombe et al (1999), the 1-5 Tinnitus Grade Scale (1-5 Grade) was developed to categorize expected type and degree of tinnitus-related

distress a patient may be expected to experience based on score ranges on the *Tinnitus Handicap Inventory* (REF). Specifically, the five grades and associated THI score ranges were:

Grade 1: No significant tinnitus-related distress. THI = 0-16. I only notice my tinnitus in quiet environments. It does not interfere with my sleep or with my daily activities. I'm not really troubled by my tinnitus.

Grade 2: Mild tinnitus-related distress. THI = 18-36. My tinnitus is easily covered up by background sounds and easily forgotten during activities. It may rarely interfere with my sleep but it does not interfere with my activities or quality of life.

Grade 3:Moderate tinnitus-related distress. THI = 38-56. I hear my tinnitus even in the presence of background sounds, but it doesn't interfere with my daily activities. My tinnitus is not quite as noticeable when I'm focused on other activities. My tinnitus occasionally interferes with my sleep and occasionally interferes with quiet activities.

Grade 4: Severe tinnitus related distress. THI = 58-76. I hear my tinnitus almost always. It is rarely if ever covered up by background sounds. My tinnitus regularly interferes with my sleep and can interfere with my ability to carry out normal daily activities.

Grade 5: Catastrophic tinnitus-related distress. 78-100.My tinnitus is always disturbing. It is a dominating problem that reduces my overall quality of life.

According to McCombe et al, “the majority of people suffering tinnitus should fall into Grades 2 and 3… Grade 4 should be uncommon… [and] Grade 5 should be extremely rare. Associated psychological pathology is likely to be found.”

The 0-10 Tinnitus Problem Scale (1-10 Scale) was suggested by Abrams (2011), on which patients are asked to rate the magnitude of their tinnitus as a problem using a scale of 0-10, where 0 means “my tinnitus is not a problem at all” and 10 means “my tinnitus is the biggest problem imaginable.” According to Abrams (2011), ratings of 7 or higher are consistent with significant tinnitus-related distress.

The Tinnitus Severity Index, or TSI, was developed by Meikle et al (1995) as a brief, 12-item screening measure of tinnitus-related distress. The TSI is best completed in INTERVIEW FORMAT rather than by PAPER/PENCIL. Patients often confuse tinnitus with hearing problems. Interview format allows the audiologist to maintain a focus on issues related to tinnitus, not perceived hearing problems. TSI scores range from 12-57, and scores of 36 or higher are consistent with severe tinnitus-related distress that may warrant specific management.

The Tinnitus Reaction Questionnaire, or TRQ (Wilson et al, 1991) was developed to specifically address a tinnitus patients reactions to tinnitus and the impact it has on the specific patient. The authors proposed that scores of $\leq$ 17 were consistent with no significant tinnitus-related distress, scores of 18-69 were consistent with significant tinnitus related distress and scores of 70-104 were consistent with “significant psychological distress related to tinnitus.” At the Atlanta VA Medical Center, extensive experience suggested that the cutoff score 18 for significant tinnitus-related distress was too low; in consultation with other VA Medical Centers

who also were using the TRQ, we adopted scores of 31 or higher as being consistent with significant tinnitus related distress.

Table 3 presents the percentage of normal-hearing tinnitus subjects with scores on various measures of tinnitus-related distress falling in the significant and non-significant distress categories. These findings reveal that the majority of normal-hearing tinnitus subjects experience significant tinnitus-related distress regardless of the specific measure that is used.

Measure	1-5 Grade (n=99)	0-10 Scale (n=31)	TSI Score (n=66)	TRQ Score (n=34)
No Significant Distress	37%	29%	26%	15%
Significant Distress	63%	71%	74%	85%

Table 3. Percentage of normal-hearing tinnitus subjects with scores on various measures of tinnitus-related distress falling in the non-significant and significant distress categories.

Because previous studies have shown the significant effect that mental health status (as evidenced by presence or absence of mental health diagnoses) has on measures of perceived tinnitus severity and tinnitus-related distress, we completed a Two-Way ANOVA with Mental Health Status (MH=Y, MH=N) and Hearing Status (HL=Y, HL=N) as the independent factors and TSI scores as the dependent factor. Only the main effect of Mental Health Status was significant (p = 0.17): presence or absence of hearing loss had no significant effect on TSI scores. The means and standard errors of all groups evaluated by the Two-Way ANOVA are presented in **Table 4**.

Group	Mean TSI Score	SEM
ALL HL=Y	38.78	0.98
ALL HL=N	37.21	2.12
ALL MH=N	**35.18**	**1.93**
ALL MH=Y	**40.81**	**1.30**
MH=N, HL=Y	35.48	1.35
MH=N, HL=N	34.88	3.63
MH=Y, HL=Y	42.08	1.41
MH=Y, HL=N	39.55	2.19

Table 4. The mean TSI scores and standard errors (SEM) for tinnitus subjects divided into groups by presence or absence of diagnosed mental health disorders (Mental Health Status: MH=Y, MH=N) and presence or absence of hearing loss (Hearing Status: HL=Y, HL=N). A Two-Way ANOVA revealed that only the effect of Mental Health Status was significant (highlighted values).

Yenigun et al (2014) reported mean TSI scores for tinnitus subjects with normal hearing ("33±12") and with hearing impairment ("32±12") but failed to examine whether there was any significant difference between the groups' mean scores, both of which are substantially lower than the mean scores reported here. Although their report is difficult to interpret, Yenigun et al (2014) also reported a significant positive correlation between hearing levels and TSI scores ($p < .05$); we observed no significant correlation between binaural 4-frequency averages and TSI scores ($r = 0.03$, $p = .78$) or between age and TSI scores ($r = -.08$, $p = .37$).

Discussion

Most studies regarding tinnitus in normal-hearing subjects has focused primarily on comparing the physiological status of their auditory systems with those of normal-hearing non-tinnitus subjects through various objective measures, such as otoacoustic emissions, evoked potentials and radiographic studies. In this study we have documented that tinnitus patients

with normal hearing thresholds experience perceived tinnitus severity and tinnitus-related distress that is not significantly different from that experienced by tinnitus patients with hearing loss. Hearing aids have been shown to provide at least some relief from tinnitus for up to 85% of hearing-impaired patients and moderate to complete relief for up to 67% of patients (Benton, 2013). Because hearing aid services typically are not available to normal-hearing tinnitus patients, other management tools, such as environmental sound enrichment (Henry et all, DATE) or specific therapeutic devices such as Tinnitus Retraining therapy (REF) Neuromonics or SoundCure (REF) may be warranted to address the negative impact on quality of life.

References