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Factors affecting severity of tinnitus - a follow-up study of tinnitus subjects at an Ear Nose Throat clinic in Sweden

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Abstract

Objective: The aim of the present study was to examine whether perceived tinnitus severity changes over time, and if so what factors contribute to this change. **Design:** A modified Swedish version of tinnitus severity questionnaire (MS-TSQ) was used to examine changes in tinnitus severity over a period of time. **Study sample:** The MS-TSQ questionnaire was completed by 455 subjects visiting an Ear, Nose and Throat (ENT) clinic in Sweden as part of baseline assessment (S_b). The same questionnaire was completed during follow-up assessment (S_f) by 174 of these subjects to examine changes in tinnitus severity, if any. The difference in scores obtained from the two assessments was calculated and was termed as difference scores (S_d). **Results:** Results of analyses of variance (ANOVA) indicated significant reduction in tinnitus severity from S_b to S_f scores ($p < 0.001$). Subjects with noise induced hearing loss showed significantly lower S_d scores than subjects with unspecified sensorineural hearing loss ($p < 0.01$). The group who received psychological treatment for tinnitus obtained significantly higher S_d than those who did not ($p < 0.01$). **Conclusions:** Results provide valuable framework for understanding the factors that affect tinnitus severity over a period of time.

Keywords: duration, hearing loss, modified swedish tinnitus severity questionnaire, psychological treatment, tinnitus severity.

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INTRODUCTION

Subjective tinnitus is defined as the perceived sensation of sounds by individuals in the absence of any external physical stimulus[1]. The sounds associated with tinnitus have been described as ringing, hissing, humming, whistling, etc[2]. The perception of tinnitus can vary with different forms and degrees of severity. Previous literature has shown that tinnitus can have a significant impact on the quality of life in terms of altered psycho-social functions. In such cases, the subjects' response to tinnitus can produce annoyance, mood changes, fear, anxiety and depression - all of which are associated with tinnitus severity[3].

Various factors can trigger the severity of tinnitus such as emotional stress, psychological factors and other physical or mental illnesses. It has been shown that many factors might affect the severity of tinnitus such as hearing loss, depression, anxiety and insomnia[4]. A previous study by Stouffer et al.[5] analyzed the factors responsible for the reduction or enhancement of tinnitus severity on 528 subjects with tinnitus. They observed that common conditions that reduced tinnitus severity were sleep, listening to TV/radio, being in noisy conditions and the most common conditions that increased tinnitus severity were noise exposure, being in a quiet place, emotional stress, loss of sleep and physical exhaustion. They also concluded that tinnitus severity increased as a function of number of years since onset.

Many theories and models have been proposed to explain the etiology of tinnitus in individuals with hearing loss and in normal hearing[6-8]. Tinnitus is often, but not always associated with the presence of a hearing loss. Most neurophysiologic evidence for tinnitus points to changes in the auditory system in individuals having hearing loss following noise exposure[9,10] and over-representation in the cortical tonotopic organization at frequencies having normal hearing thresholds[11]. Studies on the effect of noise exposure and tinnitus[12] have shown that exposure to occupational noise gave increased odds for tinnitus in subjects with hearing loss. These subjects were mainly exposed to leisure-time noise and had frequent tinnitus but their thresholds were within normal limits. Studies have suggested that being exposed to excessive noise for longer periods of time, could lead to hearing loss and tinnitus, whereas a noise exposure over a short time period, could cause tinnitus as the only symptom. Since only frequencies from 125 Hz to 8 kHz are measured in conventional pure-tone audiometry, it is possible that a person with normal hearing can have a hearing loss at frequencies higher than 8 kHz accompanied by tinnitus[13,14]. It is shown that subjects with tinnitus have steeper maximum high-frequency slopes compared to the subjects without tinnitus. Studies have argued that the presence of tinnitus is related to the boundary in the audiogram between the frequency regions of normal or near-normal hearing and a region with a higher degree of hearing loss[15,16]. These results indicate that both the degree of hearing loss and the shape of an audiogram were factors that could predict the occurrence of tinnitus.

Previous research has shown that psychoacoustic measurements of tinnitus do not always correlate with how tinnitus affects a person[17]. A variety of assessment techniques have been designed that reports subjects' tinnitus severity through questionnaires and interviews[18,19]. These assessment techniques quantify the impact of tinnitus on subjects' everyday life based on baseline and follow-up assessment scores. Axelsson and Ringdahl[10] administered a tinnitus questionnaire on a large population of randomly selected adults. It was observed that tinnitus was more often in males than in females. Also, tinnitus was more common in left ear than in the right. In relation to hearing thresholds, it was observed that, in subjects who had tinnitus always, 19% considered themselves as having normal hearing, 55% had some hearing loss, 19% had marked hearing loss and 3% were deaf. However, the study was based on subjects' own assessment of their hearing ability.

A wide range of techniques and/or devices have been advocated for the treatment of tinnitus. These techniques range from providing psychological treatments[20,21] to wearing tinnitus maskers[6,22] for subjects with tinnitus. Forti et al.[23] investigated the effect of tinnitus retraining therapy on 45 subjects having idiopathic tinnitus for at least 6 months. Results indicated that the percentage of individuals with tinnitus who reported the disappearance of difficulties in different activities such as concentration, sleep, relaxation, work and social relations improved after the end of therapy. Studies have shown that tinnitus affects a person's well being and can lead to a range of associated problems. In such cases, psychological management can be helpful for some subjects. Previous studies have shown that, with cognitive behavioral therapies it is possible to improve a person's ability to cope with his/her tinnitus[20,21]. It has also been shown that cognitive behavioral therapies can improve a person's ability to cope with their tinnitus[21]. A similar study by Andersson et al.[20] observed that the severity of tinnitus reduced over time in all of their subjects, when psychological intervention was provided.

There are few studies on how tinnitus severity changes over time and it has been observed that many subjects report to health clinics with questions about the course of tinnitus severity. The present study examined whether age, duration of follow-up, hearing thresholds, gender and/or psychological treatment has an effect on the self-reported severity of tinnitus over time. A modified

Swedish version of the Tinnitus Severity Questionnaire (MS-TSQ) developed by Axelsson and Schenkmanis[24] was used to measure the baseline and follow-up scores for assessment of tinnitus severity in the present study.

METHOD

Subjects

The subjects sample consisted of a consecutive series of 455 adult subjects who were self-referred to an ENT clinic in Lund, Sweden. Demographic details of the subjects are depicted in Table 1. Subjects generally attended with a complaint of tinnitus. All subjects underwent audiological and medical examinations to identify any abnormality in the ear condition. Audiological examination consisted of pure tone audiometry supplemented with Auditory Brainstem Response (ABR) and Magnetic Resonance Imaging (MRI) if required. The medical examination consisted of case history and an ENT examination. The study had the approval of the Ethical committee in the section of Logopedics, Phoniatrics and Audiology, Lund University.

The subjects' evaluations consisted of a baseline and a follow-up assessment. For the baseline assessment, subjects were selected from a consecutive sample of 455 adult subjects that visited the clinic between the years 2000 and 2008. During this initial visit a medical and audiological examination was performed on all subjects to identify any underlying ear diseases. In terms of baseline audiometric assessment, two pure tone averages (PTAs) were calculated - one for the low frequencies (PTA_{low} consisting of 0.5, 1 and 2 kHz) and the other for high (PTA_{high} consisting of 3, 4 and 6 kHz) frequencies. The mean audiograms for the groups of diagnoses are depicted in Table 2. All subjects filled out the MS-TSQ and their responses were documented. For the follow-up assessment, the MS-TSQ was mailed to all subjects. Of the total 455 subjects, 267 subjects (response rate of around 59%) returned back the questionnaire. However, the responses of 174 subjects (110 male and 64 female; Mean = 61 years; SD = 12.7) were considered (response rate of around 38%) based on the following inclusion criteria:

1. Subjects who had normal hearing (NH) or sensorineural hearing loss with a history of noise exposure (SNIHL) or sensorineural hearing loss with an unspecified cause (USNHL) and
2. Subjects should have responded to all the questions in the MS-TSQ

Modified Swedish version of Tinnitus Severity Questionnaire (MS-TSQ)

The Modified Swedish version of Tinnitus Severity Questionnaire (MS-TSQ) developed by Axelsson and Schenkmanis[24] (see Appendix 1 for English version of the questionnaire) was used in the present study. The questionnaire covers topics such as quality of life, concentration and effect on sleep quality. The MS-TSQ which was used in this study for both baseline and follow up assessment also contains 10 items. The MS-TSQ items are identical to those of the original TSQ, but the number of response alternatives differs. An addition of a response alternative of 'not sure' was added to the already existing four response alternatives in the original TSQ version. The subjects were asked to mark one alternative for each item. The subjects' responses were rated based on the global score obtained from the MS-

Table 1. Demographic data for tinnitus subjects (n = 174) who responded to MS-TSQ follow-up assessment (NH-normal hearing; USNHL-unspecified sensorineural hearing loss; NIHL-noise induced hearing loss; R-right ear; L-left ear; low-pure tone average for low frequencies; high-pure tone average for high frequencies).

Variable		N	Mean	SD
Age (yrs)	Male	110	60.8	12.9
	Female	64	61.2	12.4
Diagnosis	NIHL	56		
	USNHL	97		
	NH	21		
Psychological treatment	Yes	28		
	No	146		
PTA (dB HL)	Rlow	174	15.1	13.2
	Rhigh	174	33.9	21.3
	Llow	174	16.7	15.1
	Lhigh	174	37.9	22.0
Global MS-TSQ score	Baseline	174	20.1	7.4
	Follow-up	174	17.5	6.2
	Improvement	174	2.7	6.2

Table 2. Mean hearing thresholds and standard deviation (SD) for normal hearing (NH), noise induced hearing loss (NIHL) and unspecified sensorineural hearing loss (USNHL).

Diagnosis		Frequency (kHz)							
		0.25	0.5	1	2	3	4	6	8
NIHL	Mean Right	10.4	10.9	11.8	16.7	30.5	42.9	45.2	42.0
	SD	7.3	7.1	9.3	14.6	19.9	21.2	23.5	26.6
	Mean Left	9.1	10.0	13.5	22.1	36.5	46.8	51.5	49.5
	SD	8.3	7.3	11.3	19.3	24.2	22.7	24.8	26.4
USNHL	Mean Right	12.8	13.6	17.1	22.3	28.5	35.5	44.4	51.1
	SD	10.0	11.4	13.0	17.3	18.5	21.2	21.2	20.3
	Mean Left	14.1	15.8	17.2	24.1	33.5	38.9	48.8	53.7
	SD	13.9	13.7	15.0	17.5	18.3	19.2	20.2	20.7
NH	Mean Right	6.0	4.0	2.9	5.0	4.8	5.7	9.3	12.1
	SD	5.4	4.9	5.8	5.7	7.0	7.6	8.4	7.5
	Mean Left	4.8	4.5	3.1	5.2	5.0	5.7	10.0	10.5
	SD	5.6	6.1	4.9	6.4	5.5	7.5	7.7	8.6

TSQ questionnaire. Global score is defined as the sum of the scores on each item in the questionnaire. In the MS-TSQ item 1 is provided with scores ranging from 2-8, item 2 from 1-4 and items 3-10 has scores ranging from 0-4. The minimum score that a subject can receive is 2 and the maximum is 44. Subjects with a global score below 20 were classified to have mild tinnitus, while a global score above 30 was classified as severe. Subjects with global scores between 20 and 30 were classified as having moderate tinnitus[24]. The MS-TSQ was administered on all subjects in two stages - a baseline score (S_b) during the initial visit and a follow-up score (S_f) with varying duration of time after the baseline assessment. The change in the tinnitus severity was calculated as (S_b - S_f), termed as the difference scores (S_d). The duration between the baseline and follow-up assessment varied from 1 year 11 months to 9 years and 4 months.

Statistical analyses

Pearson's correlation coefficient (rho) was used to examine associations between age, improvement, and PTA's. Probability values of $p < 0.05$ were considered statistically significant. A one-way analysis of variance (ANOVA) was used to examine any significant differences between the groups with different diagnoses regarding age, PTAs, S_b, S_f, and S_d scores. A post-hoc analysis was conducted using Bonferroni correction to know if significant differences existed between groups. Independent samples t-test was used to analyze gender differences and the effect of psychological treatment. Paired-samples *t*-test was used to measure significant differences between ears. Alpha-level < 0.05 was considered statistically significant for all analyses.

RESULTS

For all subjects, an overall reduction of tinnitus severity can be seen for MS-TSQ-scores from mean baseline score (S_b) of 20.1 to mean follow-up scores (S_f) of 17.7 during the follow-up assessment. The mean difference score (S_d) was 2.7 with a standard deviation of 6.2. Results of analyses of variance (ANOVA) indicated that the reduction in the tinnitus severity scores was highly significant ($p < 0.001$). A high positive correlation was obtained between age and pure tone audiometric thresholds for the low and high frequencies (DF = 172, $\rho > 0.43$, $p < 0.001$) indicating that hearing thresholds increased as a function of age. Also, positive correlation was obtained between pure tone averages (PTAs) across both ears and was statistically significant (DF = 172, $\gamma > 0.50$, $p < 0.001$). No significant correlation was observed between improvement in tinnitus scores and other variables of age, pure tone audiometry types or duration of follow-up.

Differences between groups of subjects

A one-way ANOVA test was administered to assess significant differences, if any, in age, PTAs (low and high) and improvement in the MS-TSQ scores between the three subject groups. Descriptive data including mean, standard deviation (SD) and significance levels (p) are presented in Table 3. Results indicated that subjects with NH were significantly younger than subjects with NIHL ($p < 0.001$) and USNHL ($p < 0.001$). Subjects with NIHL had significantly better PTA_{low} than subjects with USNHL but only in the right ear ($p < 0.05$). As expected, mean PTAs for subjects with NH were significantly better than mean PTAs for the NIHL ($p < 0.05$) and USNHL ($p < 0.001$) group.

Results indicated that subjects with NH scored the least and subjects with USNHL scored the highest on the baseline MS-TSQ assessment. A significant difference was observed in the mean MS-TSQ baseline score between the NHIL and USNHL group ($p < 0.05$); and between USNHL and NH group ($p < 0.05$). No significant differences were observed among the three groups in the follow-up MS-TSQ score. In terms of the improvement in the MS-TSQ scores, the USNHL group obtained significantly lower scores than the NIHL group. No significant differences were observed in the MS-TSQ difference scores between NH and NIHL; and between NH and USNHL groups.

Independent-Sample *t*-test was used to test if there were significant gender and psychological

Table 3. Mean and standard deviation (SD) of age, pure tone averages (PTAs) and baseline (S_b), follow-up (S_f) and difference MS-TSQ scores (S_d) across different subject groups. Significance level (p) with *t*-value is depicted. 'n.s' denoted 'not significant' at $p < 0.05$ level.

		Diagnosis									
Variable		NIHL		USNHL		NH			Post-hoc comparison *p*-values		
		Mean	SD	Mean	SD	Mean	SD	F-value	NIHL-NH	NIHL-USNHL	USNHL-NH
Age (yrs)		60.5	11.1	64.8	10	44.6	15.2	28.85	< 0.001	n.s.	< 0.001
PTA (right)	Low	12.9	8.5	18.6	15.1	5	6.1	11.47	0.044	0.024	< 0.001
	High	38.4	19.7	37.1	20.2	7.1	6.4	23.93	< 0.001	n.s.	< 0.001
PTA (left)	Low	17.8	17.7	18.8	13.7	4.6	4.4	8.49	0.002	n.s.	< 0.001
	High	44.9	22.4	40.7	18.1	6.8	5.1	34.15	< 0.001	n.s.	< 0.001
Global score	Baseline (S_b)	18.3	6.5	21.8	7.8	17	5.6	6.59	n.s.	0.012	0.015
	Follow-up (S_f)	17.8	7.2	18	7.1	14.3	5.8	2.47	n.s.	n.s.	n.s.
	Difference (S_d)	0.6	5.4	3.9	6.6	2.7	5.4	5.25	n.s.	0.004	n.s.

treatment differences in age, PTAs, MS-TSQ baseline, follow-up and difference score. There was a significant difference in PTAhigh for right and left ears between genders, indicating lower hearing thresholds for females than males. No significant difference was observed between genders between other variables. In terms of psychological treatment, it was observed that subjects who received the treatment had significantly higher baseline ($p < 0.001$) and improvement ($p < 0.01$) in the MS-TSQ scores than those who did not (Table 4).

DISCUSSION

The purpose of this study was to explore the association between self-reported tinnitus severity and duration between baseline and follow-up assessment, degree of hearing loss, subject groups, age, gender and psychological treatment.

The present study assessed tinnitus severity performance obtained through questionnaires and calculated baseline scores (S_b), follow-up scores (S_f) and difference scores (S_d). Positive difference score is interpreted as an improvement, i.e. a reduction in the tinnitus severity score. The method of obtaining the responses through questionnaires sent out by mail has generally been shown to obtain a low response rate. An expected response for this kind of mail surveys is about 50%[25,26]. A study by Snow[27] concluded that a questionnaire can be a good method to assess tinnitus severity. We believe that the 'true' response rate in our study is much higher (around 59%) since 267 of the total 455 subjects initially responded to the questionnaires that were sent to them. After exclusions based on subject category and responses to all items in the questionnaire, our study yielded a final response rate of around 38% (n = 174).

The results of the preset study are in agreement with some of the earlier studies, which conclude that the severity of the tinnitus decreases over time. Previous studies have indicated that tinnitus patients experience increased tolerance over time[20,28,29]. The effect of psychological intervention on the reduction of tinnitus severity has been shown to be positive. A study by Nondahl et al.[28] assessed tinnitus severity of subjects with five years in between. Two-hundred and thirty-three patients reported significant tinnitus at the first examination, and 105 patients (45%) reported decreased annoyance during the follow-up assessment. Of these 105 patients, 45 reported no tinnitus, and 60 reported that their tinnitus had shifted from significant to mild. For 341 patients who reported mild tinnitus at baseline, 40% reported that their tinnitus had not changed, compared to 55% of the 233 who had moderate tinnitus. The study concluded that the patients were more likely to get better than get worse. In the present study, no significant associations were found between S_d scores in the MS-TSQ and age, PTA, or duration. It was observed that females had a higher MS-TSQ S_b score and a lower MS-TSQ S_f score than males. However, the findings were not significantly different between the two groups.

Similar findings were reported in earlier studies[28,30]. Previous studies have reported no significant differences between subjects with high degree tinnitus and those with mild or moderate annoyance in terms of age, gender or follow-up duration[30]. It has been shown that females seem to be at a greater risk for reporting significant tinnitus than males[28]. In terms of subject groups, around 32% of the subjects in the present study had NIHL. It is estimated that 28% of the cases with tinnitus are caused by noise exposure[10]. In our study, the NH group had the lowest S_b score among the three groups, but had a higher S_d score than subjects with NIHL. The NIHL group showed the lowest S_d score and these scores were significantly lesser compared to USNHL group ($p < 0.01$). Studies have shown that prevalence of tinnitus increases

Table 4. Mean and standard deviation (SD) of age, pure tone averages (PTAs) and baseline (S_b), follow-up (S_f) and difference MS-TSQ scores (S_d) across genders and psychologist treatment. Significance level (p) with t-value is depicted.'n.s' denoted 'not significant' at $p < 0.05$ level.

Variables		Gender						Psychological treatment					
		Men		Female				Yes	No				
		Mean	SD	Mean	SD	t-value	Sig.	Mean	SD	Mean	SD	t-value	Sig.
Age	(years)	60.8	13.0	61.2	12.4	-0.18	n.s	60.9	10.3	61.0	13.2	-0.03	n.s
PTA R	Low	14.8	13.1	15.7	13.6	-0.44	n.s	11.8	8.7	15.7	13.9	-1.43	n.s
	High	37.4	21.4	27.8	19.9	2.93	0.004	30.7	19.2	34.5	21.7	-0.87	n.s
PTA L	Low	17.9	16.4	14.8	12.3	1.28	n.s	14.1	9.5	17.3	15.9	-1.02	n.s
	High	42.3	22.6	30.4	18.6	3.52	0.001	34.1	19.4	38.7	22.4	-1.02	n.s
Global score	Baseline (S_b)	19.6	7.8	21.1	6.5	-1.31	n.s	25.4	8.7	19.1	6.7	4.34	< 0.001
	Follow-up (S_f)	17.4	7.6	17.5	6.1	-0.29	n.s	19.6	6.3	17.0	7.1	1.81	n.s
	Difference (S_d)	2.1	6.2	3.6	6.3	-1.52	n.s	5.8	7.0	2.1	5.9	2.91	0.004

due to exposure to industrial and recreational noise[1,6]. It has been shown that NIHL results in an imbalance of spontaneous and sound-driven cochlear output across different frequencies. This leads to altered central gain in the auditory system resulting in tinnitus[1]. Hence, these pathophysiological changes might be responsible for observing lesser improvement in the tinnitus severity scores in subjects with NIHL.

Results related to hearing thresholds and tinnitus scores indicated a significant difference in PTA_{low} between USNHL and NIHL in the right ear. Furthermore, it has been shown that tinnitus annoyance may increase with increasing hearing loss. In terms of gender differences, it was found that females were less annoyed by tinnitus than males[30]. The results of the present study observed that females had a higher S_b and S_d scores than males. This observation is dependent upon the hearing thresholds between the two genders. In the present study baseline audiometric measurements indicate females had significantly lower hearing thresholds in the high frequencies. The range of the duration between the baseline and follow-up visit varied from 1 year and 11 months to 9 years and 4 months and this factor might have had an effect on the audiometric thresholds during the follow-up phase.

Various studies have been carried out to investigate the effect of psychological treatment on the severity of tinnitus[20,21]. In the present study, we asked our subjects if they had received treatment from a psychologist. The subjects answered with a 'yes' or a 'no'. It is possible that the subjects may only have had a conversation or may have had further follow-up sessions with a psychologist, but those subjects who answered 'yes' in the questionnaire did receive psychological intervention. Also, no significant hearing threshold differences were observed between the groups who received psychological intervention *versus* those who did not. This finding indicates that hearing thresholds may not be the most important influencing factor on how the subjects experienced annoyance by their tinnitus, especially since the group receiving treatment had a significantly higher S_b score.

CONCLUSIONS

The present study investigated whether perceived tinnitus severity changes over time, and if so what factors contribute to this change. A modified Swedish version of the tinnitus severity questionnaire was administered to assess changes of tinnitus severity. Results indicated that mean tinnitus severity significantly reduced over time. Also, psychological intervention had an influence on the improvement in tinnitus annoyance in subjects with tinnitus. The NIHL group showed the lowest S_d score and these scores were significantly lesser compared to USNHL group. Further studies investigating the effects of the type and duration of psychological treatment on the tinnitus severity can be explored.

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Appendix 1. Modified Swedish Tinnitus Severity Questionnaire.

	Little	Moderate	A lot	Complete	Don't know
1. How much does tinnitus affect your overall quality of life?	☐	☐	☐	☐	☐
2. How much annoyance does tinnitus cause you when you are awake and staying in a quiet environment (but not trying to sleep)?	☐	☐	☐	☐	☐
	Never	**Seldom**	**Often**	**Always**	**Don't know**
3. How often do you notice tinnitus when you are awake?	☐	☐	☐	☐	☐
4. How often does tinnitus affect your concentration, for example when you read?	☐	☐	☐	☐	☐
5. How often do you have difficulties to fall asleep or go back to sleep due to tinnitus?	☐	☐	☐	☐	☐
6. How often can you suppress or "forget" tinnitus through some activity such as watching TV or talking to someone?	☐	☐	☐	☐	☐
7. If you are exposed to everyday sounds such as music, a fan, do these sounds reduce or drown your tinnitus?	☐	☐	☐	☐	☐
8. How often does tinnitus make you feel worried and concerned?	☐	☐	☐	☐	☐
9. How often does tinnitus make you feel tense and irritated?	☐	☐	☐	☐	☐
10. How often does tinnitus make you feel depressed and unhappy?	☐	☐	☐	☐	☐

Try to answer all questions. Tick only one box for each question.