Original Research

Characteristics of tinnitus and factors influencing its severity

Shanwen Chen* , **Xueqin Shen*, Jinjin Yuan, Yu Wu, Yifan Li, Busheng Tong, Jianxin Qiu, Feihu Wu and Yehai Liu**

Abstract

Background and Objectives: There is a wealth of information regarding the treatment methods for tinnitus; however, the treatment available is unsatisfactory because of the following reasons: first, tinnitus has various etiologies and second, it has distinct heterogeneity among different individuals. Numerous studies have focused on understanding the causes of tinnitus severity, but the conclusions have been inconsistent. The purpose of the present study was to define factors that differentially influence subjectively perceived tinnitus severity.

Methods: Clinical data of patients with chronic tinnitus who visited our outpatient clinic from April 2020 to April 2021 were collected. Tinnitus Handicap Inventory (THI) and Tinnitus Evaluation Questionnaire (TEQ) were used to evaluate tinnitus severity among patients, and the independent factors influencing the severity of tinnitus were investigated by performing univariate and multivariate stepwise regression analyses.

Results: Eleven variables were associated with THI and TEQ scores, of which nine were identical. Multiple regression analyses results revealed that five variables had a significantly unique predictive effect on tinnitus severity based on THI and the TEQ scores. Three factors including Self-Rating Scale of Sleep (SRSS), change in loudness, and Self-Rating Anxiety Scale (SAS) were identical.

Conclusion: Sleep status, anxiety level, and change in loudness in patients with chronic tinnitus were significantly correlated with severity of tinnitus. Follow-up studies should investigate the causal relationship between these factors and tinnitus severity.

Keywords: Self-Rating Anxiety Scale, Self-Rating Depression Scale, tinnitus, Tinnitus Evaluation Questionnaire, Tinnitus Handicap Inventory

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Introduction

Subjective tinnitus is an auditory perception, which is experienced in the absence of any external or internal auditory stimulus, and no definite organic lesions are observed after an examination. The US national health survey indicates that approximately 9.6% of adults in the US population have tinnitus.[1] The proportions of adults with tinnitus in the United Kingdom, Japan, and Nigeria are 10.1%, 18.6%, and 14.1%, respectively, with 5% having bothersome tinnitus.[2–4] The prevalence of tinnitus is expected to continue increasing with the increasing use of electronic equipment and exposure to noise. Severe and persistent tinnitus leads to comorbidities, such as sleep disorders, anxiety, or depression, and adversely affects the quality of life of patients.[5] A previous study reported that the estimated annual health care burden of tinnitus-related costs in the National Health Service (UK) was £750 million.[6] A similar study conducted in the Netherlands indicated that the direct health care costs associated with tinnitus treatment amounted to €1.9 billion.[7]

The causes of tinnitus are varied and, in most patients, tinnitus is often secondary to sudden hearing loss, noise trauma, and ototoxic drug use. Animal studies have found that these lesions can lead to abnormal neuronal activity in the central auditory pathway, which may eventually be perceived as tinnitus.[8,9] However, whether findings from the animal models can be applied to humans remain to be clarified.[10] Patients with tinnitus generally present with symptoms of hearing loss. However, a considerable percentage of patients with tinnitus do not exhibit abnormal hearing and lack distinct triggers. The uncertainty regarding the etiology of tinnitus poses a great challenge to its treatment and to the treatment options available including medications, sound therapy, tinnitus retraining therapy, cognitive behavioral therapy, and brain stimulation (invasive and non-invasive). However, due to the uncertainty of the treatment outcome, no methods have gained widespread acceptance.[11] Researchers have focused more on alleviation of the distress experienced by patients with tinnitus than on its elimination.

The severity of tinnitus seems to be influenced by several factors, including personality traits, psychosocial factors, tinnitus characteristics, among others. Numerous studies have investigated the factors influencing tinnitus severity. To investigate potential influencing factors, multivariate regression analysis should be performed while controlling for confounding variables. However, many studies did not carry out multivariate analysis.[12–17] To increase the reliability of the analysis, at least 10 participants per variable are needed. A small ratio (less than 10:1) of outcome events to independent variables increases uncertainty in risk estimates. Therefore, results from regression analyses in some studies are unreliable.[18–20] A few studies performed appropriate statistical analyses to explore the factors affecting the severity of tinnitus, but there was considerable heterogeneity among the studies. For instance, there was heterogeneity in the choice of potential variables and evaluation of tinnitus tendency difference in questionnaires. Reporting of outcomes was inconsistent across the studies and, in some cases, the outcomes were contradictory.[21–23] Hoekstra *et al.*[23] summarized previous studies that analyzed 18 factors that had been reported to be associated with tinnitus severity and 10 factors that have not been reported, and the results revealed that 3 factors have been associated with tinnitus severity based on Tinnitus Handicap Inventory (THI)

and Tinnitus Questionnaire (TQ) scales, although the results still differ from those reported in other studies.[21]

Although the potential risk factors of tinnitus severity have been reported, it remains to be clarified as to which factors have the highest contribution to severity. The aim of the present study was to address the problem by determining the factors that differentially affect subjectively perceived tinnitus-related distress. Currently, THI and Tinnitus Evaluation Questionnaire (TEQ) were used to assess the severity of tinnitus, while the Self-Rating Scale of Sleep (SRSS), Self-Rating Anxiety Scale (SAS), and Self-Rating Depression Scale (SDS) were used to assess sleep, anxiety, and depression in patients with tinnitus. Potential factors influencing tinnitus were analyzed by performing univariate analysis and the results validated using multivariate analysis.

Methods

Study participants and data collection

This study included consecutive patients with tinnitus who visited our institute from April 2020 to April 2021. Participants were required to satisfy the following inclusion criteria: (a) at least 18 years old, (b) chief complaint of tinnitus, (c) disease course lasting ≥3 months, and (d) ability to independently complete questionnaires. Exclusion criteria: tinnitus induced by other diseases. No other inclusion/exclusion criteria were applied. Incomplete and ineligible questionnaires were excluded from the analysis. The data collection was completed simultaneously at the time of patient visit, and the analysis was retrospectively completed in September 2021. The present study conformed to the principles outlined in the Declaration of Helsinki. As this was a retrospective study, and data were analyzed anonymously, the committee exempted informed consent. The present study was approved by the Research Ethics Committee of the First Affiliated Hospital of Anhui Medical University (IRB approval No. PJ 2021 14-22).

Measures

Otolaryngologists obtained data that could be associated with the severity of tinnitus, including the general information of patients (age, gender, treatment history, and family history),

characteristics of tinnitus [duration of tinnitus, location of tinnitus, number of tinnitus sounds, change in loudness, change in pitch, tinnitus loudness (Visual Analogue Scale, VAS)], and health factors (personality traits, expectations, sleep quality, anxiety, and depression). Treatment history refers to trying to take drugs, including but not limited to steroids, Ginkgo biloba extract, and traditional Chinese medicine. Pure tone audiometry, tinnitus loudness matching, and tinnitus frequency matching was carried out by an audiologist. Pure tone and narrow-band noise were used in the analysis for tinnitus frequency. Tinnitus loudness was matched by tinnitus matching frequency. Patients were evaluated into an audiological cabin and pure tone audiometry was performed on a Otometrics Audiology audiometer (Denmark). The severity of tinnitus, sleep, anxiety, and depression were evaluated using questionnaires.

Tinnitus Handicap Inventory
THI is currently the most widely used self-rating scale to evaluate tinnitus severity.[24] The scale consists of 25 questions with 3 subscales: functional, affective, and catastrophic subscales. Each question is divided into three stepwise scales of response, with a score of 100 representing the most severe degree of tinnitus. The reliability and validity of the scale were verified in previous studies.[25–27] The scale was translated into Chinese in 2007, and its reliability and validity have been validated in other studies.[28,29]

Tinnitus Evaluation Questionnaire
TEQ is a Mandarin version of the tinnitus evaluation scale consisting of six questions; the first five questions are scored three points each and the sixth question is scored six points, with a total of 21 points.[30] Questions include the perceived loudness and duration of tinnitus, the effect of tinnitus on sleep, concentration, mood, and the overall rating of tinnitus severity. A comparison between THI and TEQ revealed that TEQ had similar validity and reliability to THI in the Chinese populations and was more operational with less time required.[31,32]

Self-Rating Scale of Sleep
SRSS is a self-administered tool used to assess the severity of sleep over the last 1 month.[33] SRSS consists of 10 items that can be rated on a 5-point scale ranging from 1 to 5. Higher scores denote severe sleep disorder based on the total score.

Self-Rating Anxiety Scale
SAS has been largely used in clinical practice, and it has high reliability and validity.[34] SAS is a 20-item Likert-type scale that reflects the mood, physical discomfort, mental activity, behavior, and psychological symptoms of patients, with raw scores that range from 20 to 80, which are converted by multiplying with 1.25 and then rounded off. Score description is as follows: <50 indicates normal, 50–59 denotes mild anxiety, 60–69 denotes moderate anxiety, and ≥70 denotes severe anxiety.

Self-Rating Depression Scale
SDS is frequently used, and it has high reliability and validity.[35] The scale consists of 20 items with four scoring grades. Numbers from 1 to 4 are used for scoring based on the frequency of symptoms. The calculation method for scores is similar to that of SAS. The higher the score, the greater the level of depression.

Statistical analyses
Statistical analyses were conducted using IBM SPSS Statistics 25.0 (IBM Corp., Armonk, NY, USA). Descriptive analyses were performed for all the study variables. Univariate analyses for dichotomous variables were performed using independent sample t-tests and analysis of variance for multi-categorical variables. Effect sizes were quantified using Cohen's d metric. Least significance difference (LSD) test was adopted as a *post hoc* test to determine the differences among groups. Bivariate correlations for continuous variables were calculated (Pearson's correlation coefficient for normally distributed data and Spearman's rank correlation coefficient for non-normally distributed data). All statistical analyses for THI and TEQ were presented separately. After performing univariate analyses, variables showing a significant relationship with tinnitus severity were selected for subsequent multivariate analyses using a stepwise procedure. THI and TEQ were used as dependent variables in the analyses. The number of covariates in the multivariable model was limited to maintain at least 10 events per variable.[36] A dummy variable was

created for the number of sounds and used as a block based on the enter method for analysis. A strong correlation was defined as a correlation $\geqslant 0.50$, moderate correlation as $\geqslant 0.30$ but <0.50, and weak correlation as <0.30.[37] p values <0.05 (two-sided) were considered statistically significant.

Results

A total of 201 patients who met the inclusion criteria were included in the final analysis. Among them, 173 patients completed all the questionnaires and audiology examinations. The mean THI score was 50.2 while the mean TEQ score was 12.1. Both outcomes were normally distributed, and the correlation between THI and TEQ scores was moderate ($r=0.521$). The cohort included 107 males and 94 females, with an average age of 45.7 years and tinnitus duration of 47.2 months on average. Most patients had bilateral tinnitus and a single tinnitus sound. In the present study, most patients had sought treatments and had high expectations for the treatment outcomes. The pure tone average (PTA) was 30.64 dB HL, the matched loudness of tinnitus was 55.4 dB HL, matched tinnitus frequency was 4.4 kHz, and the average tinnitus loudness (VAS) of patients was 4.582. The detailed results are presented in Table 1. Distribution of THI scores based on categorical variables is shown in Figure 1. Distribution of TEQ scores based on categorical variables is shown in Figure 2.

Univariate relationships among variables

The results of univariate correlation analysis revealed that age was significantly associated with tinnitus severity. In addition, gender was associated with the severity of tinnitus based on THI only ($p=0.009$). Treatment and family histories of tinnitus were not associated with tinnitus severity, and similar results were observed for the factor of expectancy in both types of questionnaires. No significant correlation was observed in the personalities and THI scores of the patients, while patients with three personality types exhibited variability in the TEQ scale ($p=0.010$). Furthermore, LSD test results revealed a significant difference between patients with extroverted personality and patients who were unaware of their personality ($p=0.002$), with extroverted patients exhibiting low levels of tinnitus distress.

No significant differences were observed between introverted and extroverted patients.

Analysis of the correlation between factors influencing tinnitus and tinnitus severity revealed that six variables were significantly associated with tinnitus severity based on THI. The variables included duration, number of sounds, change in loudness, change in pitch, tinnitus loudness (VAS), and PTA. The factors also exhibited significant correlations based on TEQ analysis, in addition to change in pitch. Subsequent LSD *post hoc* tests involving the number of sounds revealed that patients hearing a single tinnitus sound had a significantly low severity based on THI and TEQ ($p=0.007$), and no difference was observed in the other groups. Weak correlation was observed between matched tinnitus loudness and tinnitus severity ($r=0.273$) based on TEQ analysis but no correlation was observed in THI analysis. Moreover, no correlation was observed between the location of tinnitus and tinnitus severity based on THI TEQ scales.

Moderate relationships were observed between SRSS, SAS, SDS, and THI ($r=0.364$, 0.406, 0.311, respectively). Same correlations were found between SRSS, SAS, SDS, and TEQ ($r=0.405$, 0.483, 0.393, respectively).

Multivariate relationships among variables

The variables that were significantly associated with severity of tinnitus in univariate analysis were entered in two separate stepwise multivariate models. Eleven variables were associated with THI and TEQ scores respectively, of which nine were identical.

Multiple regression analyses based on THI revealed that five variables exerted a significantly unique predictive effect on tinnitus severity. The scores for factors identified to be associated with tinnitus severity were all above the scores for 'SAS', followed by 'Change in loudness', 'PTA', 'SRSS', and 'Change in pitch'. The detailed results are presented in Table 2.

Analysis using TEQ as the dependent variable revealed that five variables had a significantly unique predictive effect. The most influential variables on TEQ were 'Loudness (VAS)', followed by 'SAS', 'Change in loudness', 'Matched loudness', and 'SRSS'. Three variables including

Table 1. Patient characteristics and univariate relationships with tinnitus severity.

Characteristics	Number of participants	Number (%) or mean ± SD	THI Mean ± SD	Univariate test Test statistic	p	Cohen's d	TEQ Mean ± SD	Univariate test Test statistic	p	Cohen's d
Self-report										
Age	201	45.7 ± 14.8	50.2 ± 27.0	r = 0.195	**0.006**		12.1 ± 4.1	r = 0.200	**0.004**	
Gender	201			t = −2.624	**0.009**	−0.371		t = −1.556	0.119	−0.223
Male		107 (53.2)	45.5 ± 26.7				11.7 ± 3.8			
Female		94 (46.8)	55.4 ± 26.6				12.6 ± 4.3			
Duration	201	47.2 ± 78.4		r = 0.145	**0.040**			r = 0.172	**0.015**	
Location	201			F = 0.450	0.718			F = 0.258	0.856	
Left		59 (29.4)	50.9 ± 29.0				12.1 ± 4.5			
Right		43 (21.4)	46.0 ± 28.1				11.7 ± 4.4			
Bilateral		83 (41.3)	51.7 ± 25.9				12.2 ± 3.9			
Intracranial		16 (8.0)	50.6 ± 23.4				12.7 ± 1.7			
Number of sounds	201			F = 4.480	**0.013**			F = 3.581	**0.030**	
1		146 (72.6)	46.7 ± 27.6				11.7 ± 4.0			
2		48 (23.9)	58.8 ± 23.2				13.3 ± 3.8			
>2		7 (3.5)	62.3 ± 26.5				13.9 ± 5.8			
Change in loudness	201			t = 3.981	**0.000**	0.575		t = 4.248	**<0.001**	0.616
Yes		120 (59.7)	56.2 ± 25.7				13.1 ± 4.2			
No		81 (40.3)	41.2 ± 26.6				10.7 ± 3.4			

(Continued)

Table 1. (Continued)

Characteristics	Number of participants	Number (%) or mean ± SD	THI Mean ± SD	Univariate test Test statistic	p	Cohen's d	TEQ Mean ± SD	Univariate test Test statistic	p	Cohen's d
Change in pitch	201			t=2.542	**0.012**	0.420		t=0.471	0.638	
Yes		49 (24.4)	58.6±24.8				12.4±4.3			
No		152 (75.6)	47.4±27.2				12.0±4.0			
Treatment history	201			t=−0.178	0.859			t=1.047	0.296	
Yes		135 (67.2)	49.9±26.4				12.3±4.0			
No		66 (32.8)	50.6±28.4				11.7±4.2			
Family history	201			t=0.03	0.976			t=−0.043	0.966	
Yes		37 (18.4)	50.3±26.9				12.1±4.3			
No		164 (81.6)	50.1±27.1				12.1±4.0			
Personality	201			F=1.067	0.346			F=4.740	**0.010**	
Introversion		67 (33.3)	47.6±25.4				12.1±4.1			
Extroversion		82 (40.8)	49.3±27.6				11.3±3.9			
Unclear		52 (25.9)	54.7±28.2				13.5±3.9			
Expectation	201			F=2.255	0.108			F=0.811	0.446	
High		115 (57.2)	51.3±27.1				11.9±4.0			
Moderate		60 (29.9)	44.8±26.4				12.2±4.0			
Low		26 (12.9)	57.5±26.9				13.0±4.5			
Loudness (VAS)	201	4.582±2.125		r=0.316	**<0.001**			r=0.413	**<0.001**	
Audiometric										
PTA	201	30.64±22.642		r=0.200	**0.004**			r=0.203	**0.004**	
Matching										
Loudness (dB HL)	173	55.4±24.3	49.1±26.4	r0.087	0.254		11.9±3.9	r=0.273	**<0.001**	
Frequency (kHz)	173	4.4±3.1	49.1±26.4	r=−0.052	0.498		11.9±3.9	r=0.117	0.126	
SRSS	201	24.4±7.4	50.2±27.0	r=0.364	**<0.001**		12.1±4.1	r=0.405	**<0.001**	
SAS	201	37.0±12.6	50.2±27.0	r=0.406	**<0.001**		12.1±4.1	r=0.483	**<0.001**	
SDS	201	35.4±12.0	50.2±27.0	r=0.311	**<0.001**		12.1±4.1	r=0.393	**<0.001**	

PTA, pure tone average; SAS, Self-Rating Anxiety Scale; SD, standard deviation; SDS, Self-Rating Depression Scale; SRSS, Self-Rating Scale of Sleep; TEQ, Tinnitus Evaluation Questionnaire; THI, Tinnitus Handicap Inventory; VAS, Visual Analogue Scale; A p-value in bold type means a significant difference.
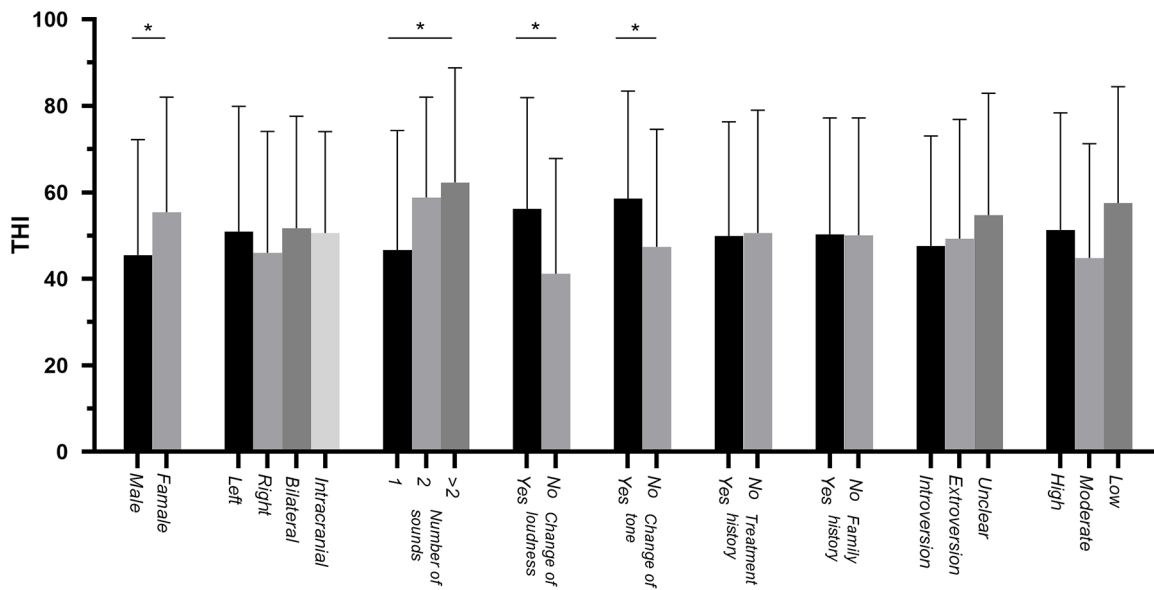
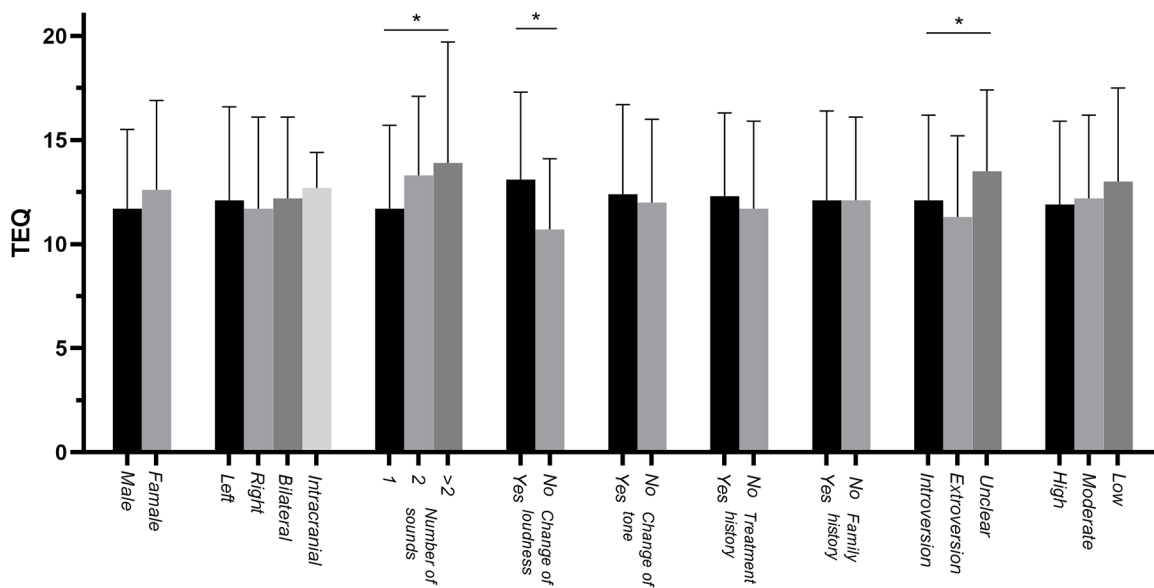**Figure 1.** Distribution of Tinnitus Handicap Inventory scores based on categorical variables.

Figure 2. Distribution of Tinnitus Evaluation Questionnaire scores based on categorical variables.

'SAS', 'Change in loudness', and 'SRSS' contributed significantly and independently in both models, which accounted for 20% of variance in the THI and 12% in the TEQ. The detailed results are presented in Table 3.

Discussion

The present study reviewed the general information of patients with tinnitus who visited our clinic between April 2020 and April 2021. The results revealed that anxiety, sleep, and change in tinnitus loudness were the relevant factors influencing the severity of tinnitus based on the THI and TEQ scales. Belli *et al.*[38] compared 90 outpatients with tinnitus to normal individuals and observed that 18.9% of the patients had anxiety disorder, and those with tinnitus had significantly higher anxiety and depression scores. The scores for patients with tinnitus were significantly higher

Table 2. Stepwise multiple regression analyses on the THI regarding tinnitus severity.

	R^2 change	β	*p*
Included			
SAS	0.144	0.238	0.001
Change in loudness	0.062	−0.220	<0.001
PTA	0.032	0.187	0.002
SRSS	0.026	0.200	0.006
Change in pitch	0.021	−0.147	0.017
Excluded			
Age			0.631
Gender			0.506
Duration			0.225
Loudness (VAS)			0.087
SDS			0.820
Number of sounds			0.416

PTA, pure tone average; SAS, Self-Rating Anxiety Scale; SDS, Self-Rating Depression Scale; SRSS, Self-Rating Scale of Sleep; THI, Tinnitus Handicap Inventory; VAS, Visual Analogue Scale.

Table 3. Stepwise multiple regression analyses on the TEQ regarding tinnitus severity.

	R^2 change	β	*p*
Included			
Loudness (VAS)	0.179	0.233	0.001
SAS	0.080	0.214	0.004
Change in loudness	0.036	−0.192	0.004
Loudness (dB HL)	0.025	0.171	0.010
SRSS	0.018	0.158	0.036
Excluded			
Age			0.368
Duration			0.895
Personality			0.625
PTA			0.699
SDS			0.209
Number of sounds			0.560

PTA, pure tone average; SAS, Self-Rating Anxiety Scale; SDS, Self-Rating Depression Scale; SRSS, Self-Rating Scale of Sleep; TEQ, Tinnitus Evaluation Questionnaire; VAS, Visual Analogue Scale.

than those of the normal controls. The results are similar to those obtained in the current study in which the SAS scale was used to quantify anxiety status of patients. Twenty-nine patients (14%) presented with anxiety, which exhibited a strong positive correlation with severity of tinnitus. A cross-sectional survey conducted by Shargorodsky *et al.*[39] revealed that frequent tinnitus was associated with generalized anxiety disorder. We used the same statistical approach that was used by Wallhäusser-Franke *et al.*[21] and Hoekstra *et al.*,[23] that is, multifactorial analysis, to further screen for potential factors influencing tinnitus severity. The results of their studies suggested that the anxiety status of patients significantly influenced tinnitus severity, although they used the Generalized Anxiety Disorder-7 (GAD-7) and Symptom Checklist-90 (SCL-90) anxiety scales. The results of the present study revealed a significant positive correlation between the quality of sleep and the severity of tinnitus in patients with tinnitus; the lower the quality of sleep, the more severe tinnitus was. The results are consistent with the findings of several previous studies.[40,41] We also evaluated changes in tinnitus loudness and pitch and observed that patients with increased tinnitus loudness over the course of the disease had relatively high THI and TEQ scores, suggesting that increased perception of tinnitus over the course of the disease could further increase the psychological burden of tinnitus on patients.

Our results are consistent with the findings of previous studies, which revealed that the general characteristics of patients with tinnitus, including gender, age, location, numbers of tinnitus, and duration of disease, are not associated with the severity of tinnitus.[19,21,23] In addition, family history of tinnitus and treatment history of the patients were analyzed; however, no correlation was observed between the two variables and the severity of tinnitus. Two studies conducted by the team of Hiller and Goebel[42,43] discussed the effect of location on the severity of tinnitus, but obtained opposite results. Yang *et al.*[44] conducted a study comparing unilateral and bilateral tinnitus and found that patients with bilateral tinnitus had higher depression and tinnitus severity than patients with unilateral tinnitus. It should not be overlooked that in the study, the prevalence of headaches was higher in patients with bilateral tinnitus, and that headaches exacerbated anxiety and depression,[45,46] which may account for the greater severity of tinnitus in patients with bilateral tinnitus. Follow-up studies with large samples should explore the specific effect of location on tinnitus severity while controlling for underlying tinnitus comorbidities. Patient personality and treatment expectancy were also included in the present study, although no correlations were observed based on THI and TEQ scores.

In the present study, we used VAS to allow patients to self-rate the loudness of their tinnitus and perform an audiometric test simultaneously to objectively match the loudness of the tinnitus. The results of univariate analysis revealed that both the loudness (VAS) and matched loudness had a significant correlation to TEQ; however, a correlation was observed only between loudness (VAS) and THI. No correlation was observed between loudness (VAS) and THI scores in the multifactorial analyses, although those were the first variables to reach significance in the TEQ model. The results were not consistent with the findings of Hoekstra *et al.*[23] in which the THI scale was used. A larger sample size was included in their study compared with our study. Moreover, patients in the present study had lower loudness (VAS) scores and higher THI scores. In addition, different variables were used in the two studies. We speculate that the aforementioned points may explain the observed discrepancy. No significant difference was observed in the correlations with THI scores when analyses were performed using matched loudness, but significant difference was observed when using loudness (VAS). Although measurement methods vary, Hoekstra *et al.*[23] suggested that loudness or matched loudness was independent of severity; however, the severity of tinnitus experienced by patients has an effect on the way loudness or pitch is perceived.

The current international tinnitus scales used include THI, TQ, Tinnitus Functional Index (TFI), and Tinnitus Reaction Questionnaire (TRQ), and the variations in the scales can lead to inconsistency in the results to a certain extent. In the present study, we used THI and TEQ to cross-validate the results and enhance the interpretation of the results. THI and TEQ results revealed a high degree of agreement, with significant correlation among 11 variables in the univariate analysis, whereas 9 variables were identical [SDS, number of tinnitus sounds, PTA, age, duration, loudness (VAS), SAS, change in loudness, SRSS]. With regard to the multivariate

analyses, the last three factors revealed significant correlations in both models. Reliable scales allow assessment of tinnitus severity, and identified potential influencing factors can facilitate rapid screening of tinnitus severity for individuals. Patients with these risk factors can be further evaluated using the scales to guide the choice of appropriate treatment.

There are no generally effective therapeutic interventions for tinnitus in current clinical application. Identifying factors that influence severity of tinnitus, therefore, has the potential to improve the quality of tinnitus management and therapies. In this study, we used appropriate statistical methods and two validated scales simultaneously, finding that anxiety and sleep quality were key factors influencing tinnitus severity. These findings further support the previous studies.[12,21,23] Follow-up study could focus on causal relationship between these factors and tinnitus severity.

Limitations

The present study was a retrospective study that obtained general information from patients with tinnitus who visited our clinic over a period of 1 year. Therefore, the sample size was small when compared with those of large population-based studies, making it difficult to fully represent the population with tinnitus. Second, participants of the present study were required to complete several questionnaires in the outpatient clinic, a process that required a great deal of time and patience. Although we eliminated questionnaires that did not met the requirements of the study during data analysis phase, the risk of potential misinterpretation and misfiling of questionnaires may still exist during the data collection process. This is especially important among participants with lower education levels. Therefore, future studies should be designed to take the risk of misinterpretation and provision of inaccurate information into account.

Conclusion

The factors influencing the severity of tinnitus are diverse, and the relationship between the factors and tinnitus severity remains unclear. Tinnitus Severity Scale is a reliable method of evaluating tinnitus severity. Although the use of different tinnitus severity scales yielded variable results, the results revealed a high degree of agreement. SAS, change in loudness, and SRSS were common factors influencing tinnitus severity based on THI and TEQ. In clinical practice, an initial determination of the severity of tinnitus should be made by interrogating these factors in patients.

Declarations

Ethics approval and consent to participate

The present study was approved by the Research Ethics Committee of the First Affiliated Hospital of Anhui Medical University. As this was a retrospective study, and data were analyzed anonymously, the committee exempted informed consent.

Consent for publication

Not applicable.

Author contributions

Shanwen Chen: Conceptualization; Data curation; Formal analysis; Methodology; Resources; Writing – original draft; Writing – review & editing.
Xueqin Shen: Data curation; Formal analysis; Methodology; Resources; Writing – original draft.
Jinjin Yuan: Conceptualization; Data curation; Resources; Writing – review & editing.
Yu Wu: Conceptualization; Data curation; Resources; Writing – review & editing.
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Availability of data and materials
All data are available from the corresponding author upon reasonable request.

Supplemental material
Supplemental material for this article is available online.

References
1. Bhatt JM, Lin HW and Bhattacharyya N. Prevalence, severity, exposures, and treatment patterns of tinnitus in the United States. *JAMA Otolaryngol Head Neck Surg* 2016; 142: 959–965.

2. Michikawa T, Nishiwaki Y, Kikuchi Y, *et al.* Prevalence and factors associated with tinnitus: a community-based study of Japanese elders. *J Epidemiol* 2010; 20: 271–276.

3. Lasisi AO, Abiona T and Gureje O. Tinnitus in the elderly: profile, correlates, and impact in the Nigerian Study of Ageing. *Otolaryngol Head Neck Surg* 2010; 143: 510–515.

4. Dawes P, Newall J, Stockdale D, *et al.* Natural history of tinnitus in adults: a cross-sectional and longitudinal analysis. *BMJ Open* 2020; 10: e041290.

5. Nondahl DM, Cruickshanks KJ, Dalton DS, *et al.* The impact of tinnitus on quality of life in older adults. *J Am Acad Audiol* 2007; 18: 257–266.

6. Stockdale D, McFerran D, Brazier P, *et al.* An economic evaluation of the healthcare cost of tinnitus management in the UK. *BMC Health Serv Res* 2017; 17: 577.

7. Maes IHL, Cima RFF, Vlaeyen JW, *et al.* Tinnitus: a cost study. *Ear Hear* 2013; 34: 508–514.

8. Baguley D, McFerran D and Hall D. Tinnitus. *Lancet* 2013; 382: 1600–1607.

9. Noreña AJ. An integrative model of tinnitus based on a central gain controlling neural sensitivity. *Neurosci Biobehav Rev* 2011; 35: 1089–1109.

10. Eggermont JJ. Hearing loss, hyperacusis, or tinnitus: what is modeled in animal research? *Hear Res* 2013; 295: 140–149.

11. Langguth B, Kreuzer PM, Kleinjung T, *et al.* Tinnitus: causes and clinical management. *Lancet Neurol* 2013; 12: 920–930.

12. Ooms E, Vanheule S, Meganck R, *et al.* Tinnitus severity and its association with cognitive and somatic anxiety: a critical study. *Eur Arch Otorhinolaryngol* 2012; 269: 2327–2333.

13. Mazurek B, Olze H, Haupt H, *et al.* The more the worse: the grade of noise-induced hearing loss associates with the severity of tinnitus. *Int J Environ Res Public Health* 2010; 7: 3071–3079.

14. Ooms E, Meganck R, Vanheule S, *et al.* Tinnitus severity and the relation to depressive symptoms: a critical study. *Otolaryngol Head Neck Surg* 2011; 145: 276–281.

15. Udupi VA, Uppunda AK, Mohan KM, *et al.* The relationship of perceived severity of tinnitus with depression, anxiety, hearing status, age and gender in individuals with tinnitus. *Int Tinnitus J* 2013; 18: 29–34.

16. Pinto PC, Sanchez TG and Tomita S. The impact of gender, age and hearing loss on tinnitus severity. *Braz J Otorhinolaryngol* 2010; 76: 18–24.

17. Unterrainer J, Greimel KV, Leibetseder M, *et al.* Experiencing tinnitus: which factors are important for perceived severity of the symptom. *Int Tinnitus J* 2003; 9: 130–133.

18. Degeest S, Corthals P, Dhooge I, *et al.* The impact of tinnitus characteristics and associated variables on tinnitus-related handicap. *J Laryngol Otol* 2016; 130: 25–31.

19. Holgers KM, Zöger S and Svedlund K. Predictive factors for development of severe tinnitus suffering-further characterisation. *Int J Audiol* 2005; 44: 584–592.

20. Andersson G, Lyttkens L and Larsen HC. Distinguishing levels of tinnitus distress. *Clin Otolaryngol Allied Sci* 1999; 24: 404–410.

21. Wallhäusser-Franke E, Brade J, Balkenhol T, *et al.* Tinnitus: distinguishing between subjectively perceived loudness and tinnitus-related distress. *PLoS ONE* 2012; 7: e34583.

22. Milerová J, Anders M, Dvořák T, *et al.* The influence of psychological factors on tinnitus severity. *Gen Hosp Psychiatry* 2013; 35: 412–416.

23. Hoekstra CE, Wesdorp FM and van Zanten GA. Socio-demographic, health, and tinnitus related variables affecting tinnitus severity. *Ear Hear* 2014; 35: 544–554.

24. Newman CW, Jacobson GP and Spitzer JB. Development of the Tinnitus Handicap Inventory. *Arch Otolaryngol Head Neck Surg* 1996; 122: 143–148.

25. Newman CW, Sandridge SA and Jacobson GP. Psychometric adequacy of the Tinnitus Handicap Inventory (THI) for evaluating treatment outcome. *J Am Acad Audiol* 1998; 9: 153–160.

26. Barake R, Rizk SA, Ziade G, *et al.* Adaptation of the Arabic Version of the Tinnitus Handicap Inventory. *Otolaryngol Head Neck Surg* 2016; 154: 508–512.

27. Monzani D, Genovese E, Marrara A, *et al.* Validity of the Italian adaptation of the Tinnitus Handicap Inventory; focus on quality of life and psychological distress in tinnitus-sufferers. *Acta Otorhinolaryngol Ital* 2008; 28: 126–134.

28. Qiulan S, Xingkuan B, Junguo W, *et al.* Translation and application of tinnitus handicap inventory in Chinese version. *J Nanjing Med Univer* 2007; 27: 476–479.

29. Meng Z, Zheng Y, Liu S, *et al.* Reliability and validity of the Chinese (mandarin) tinnitus handicap inventory. *Clin Exp Otorhinolaryngol* 2012; 5: 10–16.

30. Chen Z, Zheng Y, Fei Y, *et al.* Validation of the mandarin tinnitus evaluation questionnaire: a clinician-administered tool for tinnitus management. *Medicine (Baltimore)* 2021; 100: e26490.

31. Peng L and Yun Z. Clinical values of Tinnitus Evaluation Questionnaire. *Chin Sci J Hear Speech Rehab* 2018; 16: 411–415.

32. Liu P, Xu GL, Li M, *et al.* Study on reliability and validity of the Tinnitus Evaluation Questionnaire. *Chin J Otorhinolaryngol Head Neck Surg* 2012; 47: 716–719.

33. Jianming L. Self-Rating Scale of Sleep (SRSS). *China J Health Psychol* 2012; 20: 1851.

34. Zung WW. A rating instrument for anxiety disorders. *Psychosomatics* 1971; 12: 371–379.

35. Zung WW. A self-rating depression scale. *Arch Gen Psychiatry* 1965; 12: 63–70.

36. Peduzzi P, Concato J, Kemper E, *et al.* A simulation study of the number of events per variable in logistic regression analysis. *J Clin Epidemiol* 1996; 49: 1373–1379.

37. Cohen J. *Statistical power analysis for the behavioral sciences*. 2nd ed. New York: Routledge, 1988.

38. Belli S, Belli H, Bahcebasi T, *et al.* Assessment of psychopathological aspects and psychiatric comorbidities in patients affected by tinnitus. *Eur Arch Otorhinolaryngol* 2008; 265: 279–285.

39. Shargorodsky J, Curhan GC and Farwell WR. Prevalence and characteristics of tinnitus among US adults. *Am J Med* 2010; 123: 711–718.

40. Alster J, Shemesh Z, Ornan M, *et al.* Sleep disturbance associated with chronic tinnitus. *Biol Psychiatry* 1993; 34: 84–90.

41. Kim HJ, Lee HJ, An SY, *et al.* Analysis of the prevalence and associated risk factors of tinnitus in adults. *PLoS ONE* 2015; 10: e0127578.

42. Hiller W and Goebel G. Assessing audiological, pathophysiological, and psychological variables in chronic tinnitus: a study of reliability and search for prognostic factors. *Int J Behav Med* 1999; 6: 312–330.

43. Hiller W and Goebel G. Factors influencing tinnitus loudness and annoyance. *Arch Otolaryngol Head Neck Surg* 2006; 132: 1323–1330.

44. Yang CW, Jung J, Kim SH, *et al.* Comparison of clinical characteristics in patients with bilateral and unilateral tinnitus. *Acta Otolaryngol* 2015; 135: 1128–1131.

45. Lampl C, Thomas H, Tassorelli C, *et al.* Headache, depression and anxiety: associations in the Eurolight project. *J Headache Pain* 2016; 17: 59.

46. Nowaczewska M, Wiciński M, Straburzyński M, *et al.* The prevalence of different types of headache in patients with subjective tinnitus and its influence on tinnitus parameters: a prospective clinical study. *Brain Sci* 2020; 10: E776.