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Tinnitus and its association with mental
health and health-related quality of life in
an older population: A nationwide cross-
sectional study

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Directed by Professor Lee Yong Jae

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This certifies that the Master's Thesis
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ABSTRACT

Tinnitus and its association with mental health and health-related quality of life in an older population: A nationwide cross-sectional study

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This study investigated the relationship of tinnitus with mental health and health-related quality of life (QoL) in older people. Data source included 5,129 community-dwelling men and women ≥ 60 years old from the Korean National Health and Nutrition Examination Survey. Tinnitus was categorized into three groups: normal, tolerable tinnitus, and annoying tinnitus. Mental health and health related QoL were assessed according to three dimensions (depressive mood, psychological distress, and suicidal ideation) and five domains (impaired mobility, impaired self-care, impaired usual activities, pain/discomfort, and anxiety/depression). The odds ratios (ORs) and 95% confidence intervals (CIs) of mental health and health related QOL were calculated using multiple logistic regression

analyses. Annoying tinnitus was positively and independently associated with deteriorated mental health and health-related QoL, suggesting comprehensive care is needed in older people with annoying tinnitus.

Key words: mental health; health related quality of life; self-care; mobility

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I. INTRODUCTION

Tinnitus is generally a perception of sound within one or both ears such as a ringing, roaring, buzzing, or hissing in the absence of an external stimulus¹. Since the diagnosis of tinnitus generally depends on each individual's subjective symptoms, there is no definite diagnostic tool such as audiometric tests to evaluate tinnitus. According to the American Tinnitus Association, about 50 million people in the United States (US) have chronic tinnitus continuing for more than six months, which is also serious enough to disturb everyday life for 12 million people².

In South Korea, the prevalence rate of tinnitus was 20.7% between 2009 and 2012 and the number of patients with tinnitus has increased by 3% annually. The annual medical burden for tinnitus patients was 22.7 billion KRW in 2013 and the annual increase rate of medical cost averaged 5.6% from the Nationwide Health Claims Insurance Service (NHIS) dataset in South Korea³.

All South Korean citizens and foreigners who complete their alien registration are enrolled to obtain medical services from the NHIS system, which is a

government-affiliated organization under the Korean Ministry of Health and Welfare. According to the health care quality review of the Organization for Economic Cooperation and Development (OECD) (2012), the Korean NHIS system has been remarkably successful in supplying high quality health care services with affordable costs⁴.

It is difficult to treat tinnitus and the clinical effectiveness of medication for ameliorating tinnitus is limited from an evidence based medicine perspective⁵. Most Korean adults tend to focus primarily on otological treatment, even though tinnitus involves alteration of both auditory and non-auditory structures which include consciousness supporting and emotional networks^{6,7}. Therefore, tinnitus is closely associated with not only otological illness such as hearing impairment but also a wide spectrum of symptoms including sleep disturbance, concentration difficulty, irritation, feeling of despair, and depression. Thus, tinnitus could significantly impair a patient's quality of life (QoL)⁸. Tinnitus and depression share a number of common symptoms such as sleep disruption, concentration difficulty, feeling of despair, irritability, and social withdrawal⁹. Both tinnitus and depression also have overlapping risk factors including higher perceived stress levels, lower socioeconomic status, and chronic health problems¹⁰.

In this regard, tinnitus could contribute to deterioration in mental health and health-related QoL, particularly for the elderly. To date, several studies have presented evidence that tinnitus affects patient emotional components^{11,12}. However, no extensive population-based study has examined the relationship between tinnitus and mental health with health related QoL in a general elderly population. Thus, this study aimed to investigate the association of tinnitus with mental health and health-related QoL within a representative sample of the Korean elderly population.

II. METHODS

1. Study population

We used the secondary dataset from the Korean National Health and Nutrition Examination Survey (KNHANES-VI), which had been conducted by the Korea Centers for Disease Control and Prevention (KCDC). KNHANES is a nationally-representative, cross-sectional survey to estimate both the health condition and nutritional status of noninstitutionalized Koreans. The system of proportional sampling was performed to randomized selection of households from multi-staged stratification that was based on geographical area of the participants. The survey has three main domains: a health interview, a health examination and a nutritional investigation. The health examination is composed of anthropometry, blood pressure measurements and laboratory tests.

In this study, 6,056 participants aged 60–79 years were included from the 2013–2015 KNHANES. We excluded individuals with the following medical conditions (n=927): participants had been diagnosed with otitis media or hearing disability. Following these exclusions, a total of 5,129 participants were included in the final analysis.

2. Data collection

The 2013–2015 KNHANES included citizens' health, nutritional, demographic, and social data through the three-component survey method. Demographic information about age and lifestyle information about tobacco use, physical activity, and alcohol consumption were acquired from self-reported questionnaires. Each participant was categorized as a non-smoker, ex-smoker, or current smoker with respect to smoking status. Current drinkers were those who consumed more than 2 to 3 drinks a week for the past year. Regular exercise was defined as moderate-intensity activity ≥ 2 hours 30 minutes a week or a combination of moderate and high intensity activity ≥ 1 hour 15 minutes a week.

Height and weight were recorded to the nearest 0.1 cm and 0.1 kg, respectively (Seca 225; Seca GmbH, Hamburg, Germany; GL-6000-20; G-tech, Korea). Body mass index (BMI) was determined as the weight in kilograms divided by the square of the height in meters (kg/m^2). Systolic and diastolic blood pressures (BP) were measured three times in the right arm using a standard mercury sphygmomanometer, and the average of the last two results was used for analysis (Baumanometer; W.A. Baum Co., Inc., Copiague, NY, USA).

Because there is no standardized definition of tinnitus, we used modified queries from the United States National Health and Nutrition Examination Survey^{2,13,14}. Tinnitus was identified as responding ‘yes’ to the single question, ‘For the past executive 12 months, have you ever had ringing, roaring, or buzzing in your ears?’ This was followed by the question, ‘How much do these sounds create annoyance in your life?’. Annoying tinnitus was defined as answering ‘annoyed and bothered’ or ‘have problems getting to sleep’ to this question.

Mental health was evaluated by depressive mood, psychological distress, and suicide ideation. To assess the level of psychological distress, participants answered ‘none’, ‘mild’, ‘moderate’, or ‘severe’ to a question “How much stress do you usually feel in your daily life?” If participants reported moderate to severe, they were regarded as having stress. Depressive mood was examined using the Korean version of the World Health Organization’s Composite International Diagnostic Interview-Short Form (CIDI-SF) and participants who responded “yes” to the question “Have you ever felt melancholy or despair for two weeks during the year just past so that your daily life is interrupted?” were considered as having depressive mood. To assess suicide ideation, participants answered to the question “Have you ever thought about committing suicide within 12 months?” If the participants replied “yes”, they were regarded as having suicide ideation. After completing the mental health questionnaire, the KCDC provided education materials on depression and hot line counseling

telephone numbers to all participants in the KNHANES.

Health-related QoL was assessed using the EuroQol, which is comprised of two parts: the health-status descriptive system (EuroQoL 5-dimension, EQ-5D) and the EQ visual analog scale. The EQ-5D documents the degree of self-reported problems along five dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression)¹⁵. Each dimension is estimated based on a single question with three answer levels (no problem, some problems, and extreme problems). In addition, the EQ-5D questionnaire includes a visual analog scale ranging from 0 (worst imaginable health state) to 100 (best imaginable health state), which subjectively allows responders to rate their health.

3. Statistical analysis

Participants aged 60–79 years were categorized into three groups according to the severity of tinnitus as follows: normal, tolerable tinnitus, and annoying tinnitus. The results were expressed as mean and standard error (SE) or percentage and SE for quantitative variables. The analysis of participant characteristics according to the severity of tinnitus was conducted using a weighted two-sample t-test for continuous variables and a weighted chi-squared test for categorical variables. The odds ratios (ORs) and 95% CIs for mental health (depressive mood, psychological distress, and suicide ideation) and health-related QoL according to the severity of tinnitus were calculated using multiple logistic regression analysis. All analyses were conducted using SAS statistical software (version 9.4; SAS Institute Inc., Cary, NC, USA). All statistical tests were two-sided, and statistical significance was determined at $P < 0.05$.

4. Ethic statement

This study's protocol was reviewed and approved by the Institutional Review

Board of the KCDC (Approval No. 2013-07CON-03-4C, 2013-12EXP-03-5C). Informed consent was obtained from all participants who participated in the 2013-2015 KNHANES based on the Declaration of Helsinki.

III. RESULTS

Among the 5,129 participants aged ≥ 60 years of age, the prevalence of tinnitus was 27.6% in the prior 12 months. We observed that 15.4% and 12.2% of them experienced tolerable tinnitus and annoying tinnitus, respectively, in the previous year.

Table 1 shows the demographic and clinical characteristics of the study population according to tinnitus severity. The prevalence of hypertension was more prevalent in individuals with tinnitus (normal: 46.4 ± 0.9 , tolerable tinnitus: 53.0 ± 1.9 , annoying tinnitus: 51.0 ± 1.9 , P value = 0.001). In addition, compared with the normal group, the prevalence of type 2 diabetes has a tendency to rise as the tinnitus is worsening (normal: 18.8 ± 0.7 , tolerable tinnitus: 20.1 ± 1.5 , annoying tinnitus: 22.6 ± 1.7 , P value = 0.072). Similarly, the more severe the tinnitus, the more cardiovascular disease also tended to increase (normal: 10.7 ± 0.6 , tolerable tinnitus: 11.2 ± 1.3 , annoying tinnitus: 14.0 ± 1.4 , P value = 0.055).

Table 1. Participant characteristics according to the severity of tinnitus

	Normal	Tolerable tinnitus	Annoying tinnitus	<i>P</i> value [†]
Unweighted n (%)	3727 (72.3)	797 (15.4)	605 (12.2)	<0.001
Age (years)	68.6±0.1	68.9±0.2	70.4±0.3	<0.001
Female sex (%)	54.2±0.8	58.5±1.7	60.3±1.9	0.005
Body mass index (kg/m ²)	24.1±0.1	24.1±0.1	23.9±0.1	0.343
Systolic blood pressure (mmHg)	126.4±0.3	127.0±0.5	126.5±0.7	0.460
Diastolic blood pressure (mmHg)	73.6±0.2	72.9±0.4	71.8±0.4	0.001
Current smokers (%)	12.3±0.6	10.1±1.2	11.5±1.3	0.340
Current drinkers (%)	55.7±0.9	52.6±1.9	58.7±2.0	0.254
Regular exercise	40.9±1.2	44.2±2.5	38.2±2.4	0.216
Hypertension (%)	46.4±0.9	53.0±1.9	51.0±1.9	0.001
Type 2 diabetes mellitus (%)	18.8±0.7	20.1±1.5	22.6±1.7	0.072
Cardiovascular diseases (%) [†]	10.7±0.6	11.2±1.3	14.0±1.4	0.055

Data are expressed as the weighted mean ± SE or weighted percentage ± SE. *P* values were calculated by weighted two-sample t-test or weighted chi-squared test. Cardiovascular diseases include coronary heart diseases and ischemic strokes. Hypertension was defined as a systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, or use of hypertension medication. Type 2 diabetes was defined as a fasting plasma glucose ≥7.0 mmol/L or use of diabetes medication.

Table 2 presents the three domains of mental health including 2-week long depressive mood, psychological distress and suicidal ideations, and the proportion of impaired health-related QoL according to the severity of tinnitus.

The annoying tinnitus group showed significantly higher rates of 2-week long depressive mood (normal: 2.9 ± 0.8 , tolerable tinnitus: 18.0 ± 1.7 , annoying tinnitus: 22.3 ± 1.8 , P value < 0.001), psychological distress (normal: 16.6 ± 0.7 , tolerable tinnitus: 21.0 ± 1.5 , annoying tinnitus: 26.5 ± 2.0 , P value < 0.001) and suicidal ideations (normal: 4.8 ± 0.5 , tolerable tinnitus: 9.8 ± 1.5 , annoying tinnitus: 10.9 ± 1.6 , P value < 0.001) compared with the control group. The annoying group had a higher percentage of participants who answered “some or extreme trouble” in all of the five dimensions of the EQ-5D (impaired mobility: 45.8 ± 2.2 , impaired self-care: 18.3 ± 1.6 , impaired usual activities: 31.8 ± 1.9 , pain/discomfort: 48.3 ± 2.1 , anxiety/depression: 48.3 ± 1.8 , P value < 0.001).

Table 2. The proportion of deteriorated mental health and health-related quality of life according to the severity of tinnitus

	Normal	Tolerable tinnitus	Annoying tinnitus	P value [†]
Mental health				
Depressive mood	2.9 ± 0.8	18.0 ± 1.7	22.3 ± 1.8	< 0.001
Psychological distress	16.6 ± 0.7	21.0 ± 1.5	26.5 ± 2.0	< 0.001
Suicide ideation	4.8 ± 0.5	9.8 ± 1.5	10.9 ± 1.6	< 0.001
Health-related quality of life				
Impaired mobility	29.3 ± 0.9	35.9 ± 1.9	45.8 ± 2.2	< 0.001
Impaired self-care	8.5 ± 0.5	9.7 ± 1.1	18.3 ± 1.6	< 0.001
Impaired usual activities	17.4 ± 0.8	21.2 ± 1.7	31.8 ± 1.9	< 0.001
Pain/discomfort	31.5 ± 0.9	42.7 ± 2.1	48.3 ± 2.1	< 0.001
Anxiety/depression	14.8 ± 0.7	18.0 ± 1.5	48.3 ± 1.8	< 0.001

Data are expressed as the weighted mean \pm SE or weighted percentage \pm SE. P values were calculated by weighted two-sample t-test or weighted chi-squared test.

Figure 1 shows the mean EQ-5D index scores according to the severity of tinnitus, which were significantly lower in the group with annoying tinnitus (normal: 90.0 ± 0.3 , tolerable tinnitus: 87.8 ± 0.6 , annoying tinnitus: 82.6 ± 0.8 , P value < 0.001).

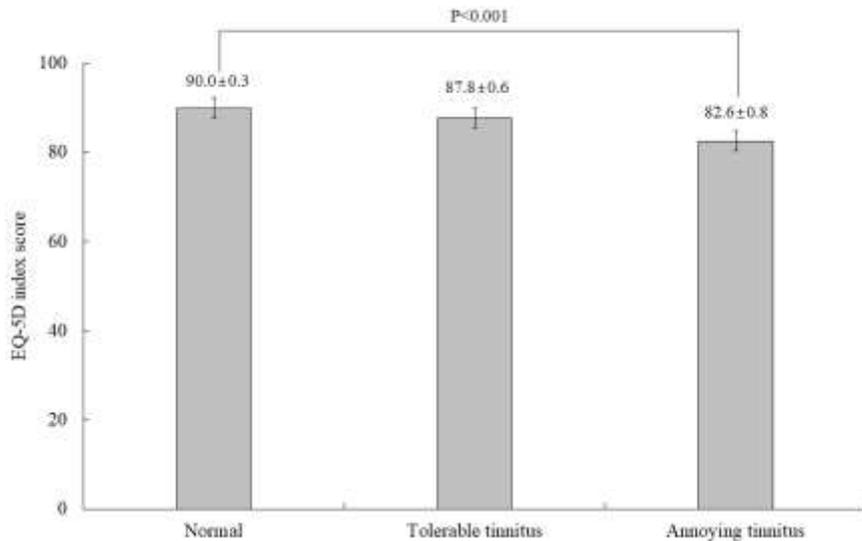


Figure 1. The mean EuroQoL five-dimension (EQ-5D) index scores according to the severity of tinnitus.

Table 3 presents differences in mental health status and health related QoL according to the severity of tinnitus after adjusting for confounding variables. Annoying tinnitus was significantly associated with depressive mood (OR [95% CI]: 1.714 [1.361–2.157]), psychological distress (OR [95% CI]: 1.934 [1.516–2.466]) and suicidal ideation (OR [95% CI]: 2.541 [1.796–3.594]) after controlling for confounds. Participants with annoying tinnitus were associated with of impaired mobility (OR [95% CI]: 1.825 [1.495–2.229]), impaired self-care (OR [95% CI]: 2.072 [1.607–2.671]), impaired usual activities (OR [95%

CI]: 2.031 [1.638-2.518), pain/discomfort (OR [95% CI]: 1.864 [1.562–2.225]) and anxiety/depression (OR [95% CI]: 2.197 [1.780–2.710]) than participants without tinnitus.

Table 3. Odds ratios for deteriorated mental health and health-related quality of life according to the severity of tinnitus

	Normal	Tolerable tinnitus	Annoying tinnitus
Mental health			
Depressive mood	1.000	1.255 (1.024–1.538)	1.714 (1.361–2.157)
Psychological distress	1.000	1.511 (1.168–1.956)	1.934 (1.516–2.466)
Suicide ideation	1.000	1.907 (1.332–2.731)	2.541 (1.796–3.594)
Health-related quality of life			
Impaired mobility	1.000	1.267 (1.039–1.545)	1.825 (1.495–2.229)
Impaired self-care	1.000	0.998 (0.753–1.323)	2.072 (1.607–2.671)
Impaired usual activities	1.000	1.177 (0.938–1.477)	2.031 (1.638–2.518)
Pain/discomfort	1.000	1.556 (1.291–1.875)	1.864 (1.562–2.225)
Anxiety/depression	1.000	1.179 (0.949–1.466)	2.197 (1.780–2.710)

Multiple logistic regression analysis included age, sex, smoking status, alcohol drinking, regular exercise, hypertension, type 2 DM, and history of cardiovascular disease.

IV. DISCUSSION

In this nationally representative sample of Korean adults aged ≥ 60 years of age, tinnitus was significantly associated with deteriorated mental health and health related QoL. Our results are in agreement with previous studies that demonstrated the association between tinnitus, depressive mood, and health related QoL, including the young population^{10,16}. Han et al. reported that tinnitus was strongly associated with psychiatric symptoms, including depression and suicidality in 28,930 Korean adults aged ≥ 19 years old. Another cross-sectional study reported

that hearing loss with tinnitus had a substantial influence on health related QoL in 11,266 adults ≥ 19 years of age¹⁶. However, to the best of our knowledge, no previous study has comprehensively examined the severity of tinnitus, mental health, and health related QoL in the elderly.

In South Korea, suicide rate among the elderly has markedly increased over the last decades. It almost doubled from 41 per 100,000 in 2001 to 80 per 100,000 in 2010, which is the highest among countries in the OECD¹⁷. Although the effectiveness of mental health care services has improved greatly over the past decades, many older adults who might benefit from these services choose not to obtain them due to the cultural background to avoid the label of mental illness and the harm in South Korea⁶. Moreover, the link between mental health and quality of life has been documented previously; thus, it is necessary to include the mental health component in the current study.

We found tinnitus severity was significantly associated with deteriorated mental health and health related QoL among older people in a dose-response manner. Although the exact mechanism underlying the observed association between tinnitus, mental health, and health related QoL is uncertain, some explanations may be offered. First, the disrupted circadian rhythm particularly associated with tinnitus could be closely linked to biological pathways associated with mental health and health related QoL. Sleep disruption is the most common complaint related to tinnitus, and the disrupted circadian rhythm could lead to a substantial increase in inflammatory markers such as C-reactive protein, tumor necrosis factor- α , and interleukin-10^{18,19}. Emerging evidence suggests that depression is associated with inflammatory reactions, as revealed by an elevated production of pro-inflammatory cytokines in the brain. The pro-inflammatory cytokines are stress-sensitive and may result in depressive behaviors through increased catabolism of the serotonin precursor tryptophan to neurotoxic tryptophan catabolites along the indoleamine oxidase pathway²⁰. Moreover, the altered pathway of serotonin transmission accompanied by pro-inflammatory

cascades could be linked to the perception of tinnitus, since serotonin plays a key role in sensory pathway networks, sense of nociception, and control of mood²¹. Experimental results have also shown that serotonin (5-HT) affects synaptic function in the dorsal cochlear nucleus which integrates auditory inputs²². Thus, serotonin dysfunction at multiple levels in the central nervous system (CNS) translates into neuroplasticity in the brain through a loss of filtering or habituation resulting in tinnitus. The elderly are also characterized by more noticeable CNS changes in essential brain structures such as the frontal cortex, amygdala, and hippocampus, and the function of these regions is critically related to serotonergic neurotransmission²³.

Second, dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis associated with chronic stress and sleep disturbances among tinnitus patients and could be closely associated with a higher risk of anxiety, mood, and stress-related disorders²⁴. The prolonged activation of the HPA axis may have an effect on mineralocorticoid receptors in the cochlea by changing the electrolyte balance and neuronal plasticity of the auditory system via glutamate neurotransmission causing tinnitus²⁵. In this regard, the disruption of the circadian rhythm may do potential harm resulting in tinnitus through not only paracrine but also endocrine balance.

There are some limitations to the interpretation of the present study. First, we do not know the relative severity or grade of tinnitus in the absence of objective testing along with more detailed questions. Second, the present study was a cross-sectional design and was unable to establish a causal relationship between tinnitus, mental health, and health related QoL. The results might reflect reverse causality and a bidirectional relationship in the association between these variables. Therefore, further prospective studies with a long follow-up period are warranted to determine whether there is a cause-and-effect relationship between tinnitus, mental health and health related QoL.

V. CONCLUSION

The elderly population with tinnitus showed deteriorated mental health and health related QoL. Given the cultural background to avoid the label of mental illness in South Korea, more comprehensive care for improving mental health and QoL might be helpful when treating older tinnitus patients.

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ABSTRACT (IN KOREAN)

이명과 노년층의 정신 건강 및 건강 관련 삶의 질과의 연관성:
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이 연구는 노인에서 이명과 정신 건강 및 건강 관련 삶의 질과의 상관 관계를 분석하였다. 국민 건강 영양 조사에서 60세 이상의 지역사회 거주 남녀 5,129명이 포함되었다. 이명은 정상, 견딜 수 있는 이명, 성가신 이명의 세 그룹으로 분류되었다. 정신 건강 및 건강 관련 삶의 질은 다음과 같은 3가지 측면(우울한 기분, 스트레스 인지, 자살 사고)과 5가지 영역(운동 능력, 자기관리, 일상활동, 통증/불편, 불안/우울)에 따라 평가되었다. 정신 건강 및 건강 관련 삶의 질의 승산 비(OR) 및 95 % 신뢰 구간(CI)은 다중 로지스틱 회귀 분석을 사용하여 계산하였다. 성가신 이명은 정신건강 악화 및 건강 관련 삶의 질과 독립적인 양의 상관관계가 있어, 성가신 이명을 가진 노인에게 포괄적인 치료가 필요함을 시사한다.

핵심되는 말: 정신건강; 건강관련 삶의 질; 자기관리; 운동능력