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# The Association between Serum Lipid Levels and Tinnitus Prevalence and Severity in Korean Elderly: A Nationwide Population-Based Cross-Sectional Study

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**Purpose:** We aimed to investigate the association between serum lipid level and tinnitus risk in Korean older adults.
**Materials and Methods:** This study used data from the 2016–2018 Korea National Health and Nutrition Examination Survey. Overall, 6021 subjects aged ≥60 years were included. Hypertriglyceridemia was defined as a serum triglyceride level of ≥200 mg/dL. The high-risk threshold of the total cholesterol (TC)/high-density lipoprotein cholesterol (HDL-C) ratio was defined as above 5.0. The presence of tinnitus was assessed via health interviews. Tinnitus severity was classified as "not annoying," "irritating," and "severely annoying and causing sleep problems." Multivariate logistic regression analysis was performed to examine the association between serum lipid level and tinnitus risk.
**Results:** The odds ratio (OR) of tinnitus was 1.27-times higher in the group with hypertriglyceridemia than in the group without hypertriglyceridemia after adjusting for age, sex, hypertension, diabetes, dyslipidemia, anemia, current smoking, obesity, noise exposure, stress cognition, and depressive mood or anxiety [95% confidence interval (CI) 1.04–1.56, $p$=0.022]. The OR of tinnitus was 1.21-times higher in the group with a high TC/HDL-C ratio than in the group without a high TC/HDL-C ratio after adjusting for the same variables as above (95% CI 1.02–1.44, $p$=0.025).
**Conclusion:** This study revealed that hypertriglyceridemia and high TC/HDL-C ratio were significantly associated with an increased OR of tinnitus in Korean older adults.

**Key Words:** Serum lipid level, hypertriglyceridemia, high total cholesterol/high-density lipoprotein cholesterol ratio, tinnitus, elderly

## INTRODUCTION

Tinnitus is the perception of sound from the ears or head, occurring without an external stimulus.[1] Tinnitus is common and its prevalence increases with age,[2] peaking at 14.3% in the age group of 60–69 years.[3] Tinnitus reduces the quality of life of affected individuals, and may lead to serious psychosocial complications in older adults.[4]

However, few risk factors for tinnitus are known.[3] Studies have shown that the incidence of dyslipidemia[5,6] and serum total cholesterol (TC), triglyceride, and low-density lipoprotein cholesterol (LDL-C) levels in the tinnitus group were higher than those in the control groups, implicating altered lipid metabolism in the etiology of tinnitus.[7] These studies have suggested that dyslipidemia is a risk factor for tinnitus; indeed, an association between dyslipidemia and insufficient microcirculation in the inner ear has been proposed as a candidate mechanism of tinnitus,[7] but the exact mechanism remains unclear.

To our knowledge, no previous study has examined the as-

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sociation between quantitative serum lipid levels and the prevalence or severity of tinnitus in older adults. Therefore, in this study, we aimed to investigate this association in Korean older adults, using data from the Korea National Health and Nutrition Examination Survey (KNHANES). In addition, we analyzed the differences in tinnitus severity according to serum lipid levels.

## MATERIALS AND METHODS

### Study population

This cross-sectional study used data from the 2016–2018 KNHANES. The KNHANES is a nationwide survey of the general health and nutrition status of all civilian, non-institutionalized Koreans, conducted by the Korean Ministry of Health and Welfare and the Division of Health and Nutrition Research, and Analysis of the Korean Centers for Disease Control and Prevention.

Among 24269 subjects from the 2016–2018 KNHANES, 6710 were aged ≥60 years; after excluding subjects with hearing loss, sinusitis, and otitis media, the number of eligible subjects was 6409. Subjects without data on serum lipid levels and those with an incomplete tinnitus questionnaire were also excluded. Finally, data from 6021 subjects were included in the analysis (Fig. 1).

All participants provided written informed consent before participating in the study, and the KNHANES was conducted following the ethical approval of the Institutional Review Board of the Korea Centers for Disease Control and Prevention (KNHANES was exempt from an ethics review, based on the bioethics and safety act from 2016 to 2017,[8] No. 2018-01-03-P-A in 2018). The protocol of this study was approved by the Institutional Review Board of Yonsei University, Seoul, Korea (No. 2021-1363-001).

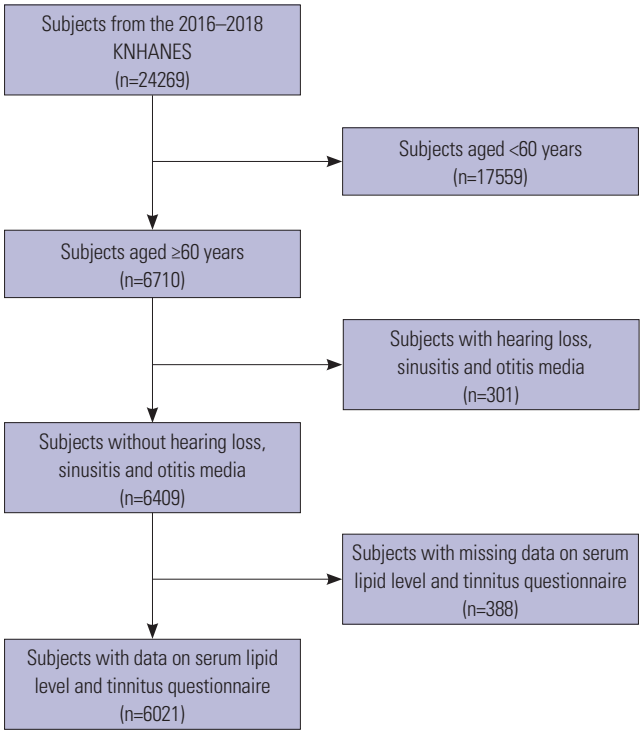


**Fig. 1.** Subjects inclusion flow chart. KNHANES, Korean National Health and Nutrition Examination Survey.

### Data collection

Subjects were interviewed by trained staff using standardized health questionnaires that collected demographic and clinical information, including medical history, smoking status, and anthropometric data. In the otolaryngologic interview, tinnitus, hearing loss, and noise exposure were surveyed. Participants were asked about their experience of tinnitus in the past year; those that reported a history of tinnitus were then asked about any annoyance that tinnitus caused in their lives on a scale of "not annoying," "irritating," and "severely annoying and causing sleep problems." Subjects who reported that they "could not hear at all" were considered to have hearing loss, and noise exposure was categorized as at the workplace for >3 months, at a place other than the workplace for >5 hours per week, or exposure to instantaneous loud noise, such as that from firearms and explosions. Stress cognition was considered present in participants reporting "a lot" or "very much" stress during everyday life, and depressive mood or anxiety were considered present in participants reporting "somewhat" or "very severe" depressive or anxiety symptoms. Participants who smoked ≥100 cigarettes in their lifetime and those who continued smoking were considered current smokers.

Hypertension, diabetes, and dyslipidemia were defined as diagnosed by a physician, and anemia was defined as a hemoglobin level of <13 g/dL in male and <12 g/dL in female. Obesity was defined as body mass index ≥25 kg/m$^2$, calculated by dividing weight (kg) by the square of height (m$^2$). Hypertriglyceridemia was defined as a serum triglyceride level of ≥200 mg/dL, and hyper-LDL cholesterolemia as a serum LDL-C level of ≥130 mg/dL.[9] The high risk threshold of the TC/high-density lipoprotein cholesterol (HDL-C) ratio, which is an indicator of increased risk of atherosclerosis and a predictor of subsequent coronary heart disease,[10] was defined as >5.0.[11,12] Serum TC, triglyceride, HDL-C, and LDL-C levels were measured using an automatic analyzer (Hitachi 7600; Hitachi, Tokyo, Japan).

### Statistical analysis

The KNHANES uses a stratified, multistage, clustered probability sampling method for the selection a representative sample of non-institutionalized, civilian Korean population. Therefore, the statistical analyses in this study were conducted by adopting stratification, clustering, and weight variables.

The participants' characteristics were stratified based on

their tinnitus status, and reported as means and standard errors for continuous variables and as unweighted numbers and percentages for categorical variables. They were compared using an independent t-test for continuous variables and a chi-squared test for categorical variables. In subjects with tinnitus, continuous variables, stratified according to tinnitus severity, were compared using a one-way analysis of variance, and the Bonferroni method was used for post-hoc analysis.

Multivariable logistic regression analysis was performed to examine the association between hypercholesterolemia, hypertriglyceridemia, hypo-HDL cholesterolemia, hyper-LDL cholesterolemia, and high TC/HDL-C ratio and tinnitus. Furthermore, the associations between serum triglyceride level and TC/HDL-C ratio and tinnitus severity were examined, which showed significant values in the above results. Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated through multivariate logistic regression analysis. We adjusted for multiple variables that showed significant associations in univariate analysis and those with clinical relevance. After calculating the crude ORs (Model 1), Model 2 was adjusted for age and sex. Model 3 was further adjusted for hypertension, diabetes, dyslipidemia, and anemia. Model 4 was adjusted for current smoking, obesity, noise exposure, stress cognition, and depressive mood or anxiety, in addition to the variables included in Model 3.

All variables included in logistic regression analysis were examined for multi-collinearity, and only those variables with a variance inflation factor of <5 were used. All statistical analyses were performed using IBM SPSS version 25 (IBM Corp., Armonk, NY, USA). The level of statistical significance was set at two-tailed $p$-values <0.05.

## RESULTS

### Demographic characteristics of study subjects

A total of 6021 subjects were included in this study (Fig. 1). Table 1 shows the demographic characteristics of the subjects according to their tinnitus status. The tinnitus group included 1733 (28.78%) participants. The mean age was 70.13±0.19 years, and there were 1001 (56.1%) females in the tinnitus group. The group with tinnitus was older and had higher proportions of hypertension, noise exposure, stress cognition, and depressive mood or anxiety compared to the group without tinnitus (all $p$<0.05).

Table 2 shows the demographic characteristics of subjects with tinnitus according to tinnitus severity. Among 1733 participants with tinnitus, 948, 647, and 138 classified their tinnitus as not annoying, irritating, and severely annoying, respectively. The group who described their tinnitus as severely annoying had high triglyceride level and TC/HDL-C ratio, as well as the highest proportions of female subjects and subjects with anemia, stress cognition, and depressive mood or anxiety (all $p$<0.05).

### Association between serum lipid level and tinnitus

Table 3 shows the ORs and 95% CIs for tinnitus according to lipid levels in 6021 Korean adults aged ≥60 years. The model was adjusted for age, sex, hypertension, diabetes, dyslipidemia, anemia, current smoking, obesity, noise exposure, stress cognition, and depressive mood or anxiety. The OR of tinnitus was 1.27-times higher in the group with hypertriglyceridemia than in the group without hypertriglyceridemia (95% CI 1.04–1.56 for Model 4). The OR of tinnitus was 1.21-times higher in the group with high TC/HDL-C ratio than in the group without high TC/HDL-C ratio (95% CI 1.02–1.44 for Model 4).

### Association between serum lipid level and tinnitus severity

Table 4 shows the ORs and 95% CIs for tinnitus severity according to serum triglyceride levels in 1733 Korean adults aged ≥60 years with tinnitus. The model was adjusted for the same

**Table 1.** Demographic Characteristics of Korean Adults Aged ≥60 Years According to Tinnitus Status

| Variables | Tinnitus (+) (n=1733) | Tinnitus (-) (n=4288) | *p* value |
|---|---|---|---|
| Age (yr) | 70.13±0.19 | 69.00±0.14 | <0.001 |
| Female | 1001 (56.1) | 2388 (54.5) | 0.329 |
| BMI (kg/m$^2$) | 24.14±0.09 | 24.27±0.05 | 0.214 |
| Obesity* | 653 (37.2) | 1614 (37.8) | 0.680 |
| TC (mg/dL) | 188.12±1.15 | 187.97±0.69 | 0.905 |
| Triglyceride (mg/dL) | 139.36±2.46 | 139.82±1.97 | 0.875 |
| HDL-C (mg/dL) | 48.33±0.33 | 48.45±0.21 | 0.754 |
| LDL-C (mg/dL) | 109.34±2.44 | 110.89±1.61 | 0.602 |
| TC/HDL-C ratio | 4.08±0.04 | 4.06±0.02 | 0.591 |
| Diagnosis | | | |
| Hypertension | 928 (52.3) | 2130 (48.9) | 0.039 |
| Diabetes | 354 (20.5) | 861 (19.2) | 0.341 |
| Dyslipidemia | 619 (35.2) | 1,390 (32.5) | 0.086 |
| Anemia† | 221 (12.6) | 474 (11.1) | 0.164 |
| Current smoking | 187 (11.5) | 477 (11.8) | 0.625 |
| Noise exposure‡ | 944 (56.3) | 2,005 (47.5) | <0.001 |
| Stress cognition§ | 393 (22.7) | 750 (17.9) | <0.001 |
| Depressive mood or anxiety¶ | 289 (15.8) | 486 (11.5) | <0.001 |

BMI, body mass index; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.
Data were obtained from the 2016–2018 Korean National Health and Nutrition Examination Survey. $p$-values were calculated using an independent t-test or chi-squared test. Continuous variables are expressed as the means and standard errors, whereas categorical variables are expressed as unweighted numbers and percentages.
*BMI of ≥25 kg/m$^2$; †Hemoglobin level of <13 g/dL in male and <12 g/dL in female; ‡Defined as at a workplace for >3 months, at a place other than the workplace for >5 hours per week, or having been exposed to instantaneous loud noise, such as noise from firearms and explosions; §Defined as a reporting "a lot" or "very much" stress in daily life; ¶Defined as reporting "somewhat" or "very severe" symptoms of depression or anxiety.


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**Table 2.** Demographic Characteristics of Korean Adults Aged ≥60 Years with Tinnitus According to Tinnitus Severity

| Variables | Severity of tinnitus | | | *p* value |
|---|---|---|---|---|
| | Not annoying (n=948) | Irritating (n= 647) | Severely annoying (n=138) | |
| Age (yr) | 70.27±6.50 | 71.19±6.38‖ | 71.27±6.26 | 0.012 |
| Female | 509 (53.7) | 395 (61.1)‖ | 97 (70.3)‖ | <0.001 |
| BMI (kg/m$^2$) | 24.17±3.12 | 24.13±3.32 | 24.67±2.84 | 0.177 |
| Obesity* | 344 (36.8) | 245 (38.1) | 64 (46.7) | 0.082 |
| TC (mg/dL) | 186.98±40.82 | 187.77±39.01 | 190.48±39.80 | 0.624 |
| Triglyceride (mg/dL) | 137.31±81.50 | 135.07±79.54 | 155.93±130.37** | 0.033 |
| HDL-C (mg/dL) | 48.23±11.82 | 48.54±11.90 | 47.39±12.28 | 0.576 |
| LDL-C (mg/dL) | 107.79±36.22 | 111.42±35.62 | 105.15±34.11 | 0.621 |
| TC/HDL-C ratio | 4.05±1.14 | 4.05±1.17 | 4.33±2.14‖ | 0.047 |
| Diagnosis | | | | |
| Hypertension | 495 (52.2) | 351 (54.3) | 82 (59.9) | 0.220 |
| Diabetes | 189 (19.9) | 135 (20.9) | 30 (21.9) | 0.815 |
| Dyslipidemia | 329 (34.7) | 236 (36.5) | 54 (39.4) | 0.491 |
| Anemia† | 102 (10.8) | 95 (14.8)‖ | 24 (17.4)** | 0.016 |
| Current smoking | 116 (12.4) | 60 (9.4) | 11 (8.3) | 0.103 |
| Noise exposure‡ | 538 (56.8) | 327 (50.5)‖ | 79 (57.2) | 0.040 |
| Stress cognition§ | 170 (18.2) | 171 (26.8)‖ | 52 (39.4)** | <0.001 |
| Depressive mood or anxiety¶ | 122 (13.3) | 129 (20.9)‖ | 38 (30.6)‖ | <0.001 |

BMI, body mass index; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.
Data were obtained from the 2016–2018 Korean National Health and Nutrition Examination Survey. *p*-values were calculated using a one-way analysis of variance or chi-squared test, and the Bonferroni method was used for post-hoc analysis. Continuous variables are expressed as the means and standard errors, whereas categorical variables are expressed as unweighted numbers and percentages.
*BMI of ≥25 kg/m$^2$; †Hemoglobin level of <13 g/dL in male and <12 g/dL in female; ‡Defined as at a workplace for >3 months, at a place other than the workplace for >5 hours per week, or having been exposed to instantaneous loud noise, such as noise from firearms and explosions; §Defined as a reporting "a lot" or "very much" stress in daily life; ¶Defined as reporting "somewhat" or "very severe" symptoms of depression or anxiety; ‖$p$<0.05 by post-hoc analyses when compared to the "not annoying" group; **$p$<0.05 by post-hoc analyses when compared to the "irritating" group.

**Table 3.** Unadjusted and Adjusted ORs and 95% CIs for Tinnitus According to Lipid Levels in Korean Adults Aged ≥60 Years

| Multivariable model | Model 1 OR (95% CI) | Model 2 OR (95% CI) | Model 3 OR (95% CI) | Model 4 OR (95% CI) |
|---|---|---|---|---|
| Tinnitus | | | | |
| Hypertriglyceridemia* (-) | Reference | Reference | Reference | Reference |
| Hypertriglyceridemia (+) | 1.18 (0.97–1.43) | 1.22 (1.01–1.49) | 1.21 (1.00–1.48) | 1.27 (1.04–1.56) |
| Hyper LDL cholesterolemia† (-) | Reference | Reference | Reference | Reference |
| Hyper LDL cholesterolemia (+) | 1.06 (0.73–1.52) | 1.06 (0.73–1.53) | 1.13 (0.77–1.65) | 1.03 (0.70–1.54) |
| High TC/HDL-C ratio‡ (-) | Reference | Reference | Reference | Reference |
| High TC/HDL-C ratio (+) | 1.14 (0.98–1.34) | 1.15 (0.98–1.35) | 1.18 (1.002–1.38) | 1.21 (1.02–1.44) |

OR, odds ratio; CI, confidence interval; LDL, low-density lipoprotein; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol.
Data were obtained from the 2016–2018 Korean National Health and Nutrition Examination Survey. Model 1 was crude. Model 2 was adjusted for age and sex. Model 3 was adjusted for hypertension, diabetes, dyslipidemia, and anemia in addition to the variables included in Model 2. Model 4 was adjusted for current smoking, obesity, noise exposure, stress cognition, and depressive mood or anxiety in addition to the variables included in Model 3 (adjusted R squared for model 1 to 4 were 0.001, 0.007, 0.008, and 0.036, respectively).
*Serum triglyceride level of ≥200 mg/dL; †Defined as a serum LDL level of ≥130 mg/dL; ‡Defined as above 5.0.

variables as those used in the previous analysis. As the serum triglyceride level increased, the OR of tinnitus severity was 1.003-times higher in the group with severely annoying tinnitus than that in the group without annoying tinnitus (95% CI 1.001–1.005 for Model 4).

Table 5 shows the ORs and 95% CIs for tinnitus severity according to serum TC/HDL-C ratio in 1733 Korean adults aged ≥60 years with tinnitus. The model was adjusted for the same variables as those used in the previous analysis. As the serum TC/HDL-C ratio increased, the OR of tinnitus severity was 1.20-times higher in the group with severely annoying tinnitus than that in the group without annoying tinnitus (95% CI 1.08–1.35 for Model 4).

**Table 4.** Association between Serum Triglyceride Level (mg/dL) and Tinnitus Severity in Korean Adults Aged ≥60 Years with Tinnitus (n=1733)

| Multivariable model | Model 1 OR (95% CI) | Model 2 OR (95% CI) | Model 3 OR (95% CI) | Model 4 OR (95% CI) |
|---|---|---|---|---|
| Severity of tinnitus | | | | |
| Not annoying | Reference | Reference | Reference | Reference |
| Irritating | 1.00 (0.998–1.001) | 1.00 (0.998–1.001) | 1.00 (0.998–1.001) | 1.00 (0.998–1.001) |
| Severely annoying | 1.002 (1.001–1.004) | 1.003 (1.001–1.005) | 1.003 (1.001–1.005) | 1.003 (1.001–1.005) |

OR, odds ratio; CI, confidence interval
Data were obtained from the 2016–2018 Korean National Health and Nutrition Examination Survey. Model 1 was crude. Model 2 was adjusted for age and sex. Model 3 was adjusted for physician-diagnosed hypertension, diabetes, dyslipidemia, and anemia in addition to the variables included in Model 2. Model 4 was adjusted for current smoking, obesity, noise exposure, stress cognition, and depressive mood or anxiety in addition to the variables included in Model 3 (adjusted R squared for model 1 to 4 were 0.003, 0.021, 0.026, and 0.058, respectively).

**Table 5.** Association between Serum Total Cholesterol/High-Density Lipoprotein Cholesterol Ratio and Tinnitus Severity in Korean Adults Aged ≥60 Years with Tinnitus (n=1733)

| Multivariable model | Model 1 OR (95% CI) | Model 2 OR (95% CI) | Model 3 OR (95% CI) | Model 4 OR (95% CI) |
|---|---|---|---|---|
| Severity of tinnitus | | | | |
| Not annoying | Reference | Reference | Reference | Reference |
| Irritating | 0.98 (0.89–1.08) | 0.99 (0.90–1.09) | 1.00 (0.90–1.10) | 0.98 (0.89–1.09) |
| Severely annoying | 1.17 (1.05–1.30) | 1.19 (1.07–1.34) | 1.21 (1.09–1.36) | 1.20 (1.08–1.35) |

OR, odds ratio; CI, confidence interval
Data were obtained from the 2016–2018 Korean National Health and Nutrition Examination Survey. Model 1 was crude. Model 2 was adjusted for age and sex. Model 3 was adjusted for physician-diagnosed hypertension, diabetes, dyslipidemia, and anemia in addition to the variables included in Model 2. Model 4 was adjusted for current smoking, obesity, noise exposure, stress cognition, and depressive mood or anxiety in addition to the variables included in Model 3 (adjusted R squared for model 1 to 4 were 0.002, 0.019, 0.023, and 0.048, respectively).

## DISCUSSION

This cross-sectional study based on data from the 2016–2018 KNHANES showed that the OR of tinnitus was higher in the group with hypertriglyceridemia and high TC/HDL-C ratio than in the group without hypertriglyceridemia and high TC/HDL-C ratio in Korean adults aged ≥60 years, respectively. Moreover, as serum triglyceride level and TC/HDL-C ratio increased, the OR of tinnitus severity was higher in the group with severely annoying tinnitus than that in the group without annoying tinnitus. To the best of our knowledge, this is the first study to quantitatively evaluate the association between serum lipid levels and tinnitus risk and severity in older adults.

Several candidate mechanisms of dyslipidemia-induced tinnitus have been proposed, including ischemia of the inner ear.[13] The most common cause of tinnitus is the disturbance of cochlear microcirculation and turbulence or reduced blood flow in the inner ear due to high lipid levels.[14-16] Increased blood viscosity and reduced blood perfusion in the stria vascularis of the cochlea may lead to impaired inner ear function, resulting in tinnitus.[17-19] Moreover, prolonged chronic hypoxia induces consequent oxidative stress and causes activation of the inflammatory cascade.[20,21] It may also lead to the death of the cochlea and decreased function of the inner ear, leading to tinnitus.[22] Furthermore, high lipid levels may lead to direct deposition of lipids at the outer hair cell membrane, resulting in compromised blood supply causing chronic hypoxia that disturbs cochlear metabolism[13] and adversely affects the capability of antioxidant enzymes.[23]

In the present study, as the serum triglyceride and TC/HDL-C levels increased, the OR of tinnitus severity was higher in the group with severely annoying tinnitus than that in the group without annoying tinnitus. Hypertriglyceridemia may be related to oxidative stress,[24] while tinnitus severity may decrease when triglyceride levels are lowered from high to normal in patients with tinnitus.[23] The TC/HDL-C ratio is known as the atherogenic index (AI)[25,26]; this ratio is a better predictor of the risk for coronary heart disease than are either TC or LDL-C levels,[11] and a marker of generalized vascular disease, including microvascular disease involving the stria vascularis in the lateral wall of the cochlea.[27,28] Therefore, based on our findings, tinnitus may be associated with impaired blood supply, chronic hypoxia, and oxidative stress of the inner ear caused by high serum triglyceride levels and TC/HDL-C ratio.

This study had some limitations. First, although this study demonstrated a statistically significant association of serum triglyceride and AI, a comprehensive indicator which contains both non-HDL-C and HDL-C,[29] and tinnitus and its severity, causality could not be assessed due to the cross-sectional design of the study. Future prospective and longitudinal studies with large samples are required to elucidate the relationship between each lipid profile and tinnitus. Second, tinnitus is a multi-causal condition in older adults; contributing factors may include otologic, metabolic, neurologic, psychological, and cardiovascular conditions, and medication.[30] However, the present study used the KNHANES data; thus, we were un-


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able to collect detailed information on other variables that may affect the risk and severity of tinnitus. Further research is required to elucidate these factors. Third, since the diagnosis of tinnitus was based on self-reports, these findings may be subject to recall bias; in addition, tinnitus prevalence may have been underreported, particularly in cases where tinnitus did not affect the participants' daily life or where tinnitus was temporary. However, tinnitus is subjective, as it can be perceived only by the patient; therefore, both diagnosis and monitoring rely on self-reported information,[4] which is associated with reasonable sensitivity (>78%).[31]

The strength of this study is that, to our knowledge, it is first to quantitatively analyze the association between serum lipid level and tinnitus risk and severity in older adults, based on a nationwide and representative sample. Tinnitus is a very common and potentially disabling condition in older adults, but no effective treatment has been established.[32] Therefore, identifying potentially vulnerable groups in a large, nationally representative study is important for the prevention, management, and decreasing the burden of this condition.[3] Moreover, since the proportion of discomfort due to annoying tinnitus is high among older adults,[33] efforts to reduce the prevalence and severity of tinnitus are important. Based on the present findings, lipid levels should be monitored in older adults with tinnitus to aid the diagnosis and treatment of this condition. In conclusion, this quantitative cross-sectional analysis of data from the 2016–2018 KNHANES revealed that the hypertriglyceridemia and high TC/HDL-C ratio were significantly associated with tinnitus. These findings indicate that identifying and treating high serum lipid levels in older adults may help prevent tinnitus onset and severity progression.

## AVAILABILITY OF DATA AND MATERIAL

The datasets analyzed in the current study are available in the [The KNHANES] repository [https://knhanes.cdc.go.kr/knhanes/index.do]. The KNHANES is a nationwide population-based survey conducted by the Korean Ministry of Health and Welfare and the Division of Chronic Disease Surveillance of the Korean Centers for Disease Control and Prevention. All data are fully available without restriction. All data files are available from the KNHANES database.

## AUTHOR CONTRIBUTIONS

Conceptualization: all authors. Data curation: Hye Jun Lee and Choon Ok Kim. Formal analysis: Hye Jun Lee. Investigation: Hye Jun Lee. Methodology: Hye Jun Lee and Choon Ok Kim. Project administration: Duk Chul Lee and Choon Ok Kim. Resources: Hye Jun Lee. Software: Hye Jun Lee. Supervision: Duk Chul Lee and Choon Ok Kim. Validation: Duk Chul Lee and Choon Ok Kim. Visualization: Hye Jun Lee. Writing—original draft: Hye Jun Lee. Writing—review & editing: Duk Chul Lee and Choon Ok Kim. Approval of final manuscript: all authors.

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