



Relationship Between Diet and Tinnitus: Korea National Health and Nutrition Examination Survey

Doh Young Lee · Young Ho Kim

Department of Otorhinolaryngology-Head and Neck Surgery, SMG-SNU Boramae Medical Center,
Seoul National University College of Medicine, Seoul, Korea

Objectives. This study aimed to analyze the association between nutritional intake and tinnitus prevalence by evaluating a large cross-sectional cohort.

Methods. Data from the Korea National Health and Nutrition Examination Survey collected between 2013 and 2015 were analyzed. The study population consisted of 7,621 individuals aged 40 to 80 years with complete tinnitus-related data. Individuals with inadequate responses to tinnitus history, noise exposure in the work place, or subjective hearing loss were excluded. Prevalence of tinnitus and tinnitus-related annoyance, and nutrition intake were measured using this questionnaire, and associations between tinnitus and nutritional data were evaluated by binary logistic regression analysis.

Results. Subjective tinnitus was reported by 1,435 individuals with subjective normal hearing (18.8%). Prevalence of tinnitus increased with age. However, among individuals with tinnitus, the proportion of individuals with tinnitus-related annoyance was similar across age groups. Older age, female sex, lower body mass index (BMI), and less vitamin B₂ intake were significantly associated with tinnitus ($P < 0.001$, $P = 0.002$, $P = 0.041$, $P = 0.013$, respectively). Vitamin B₂ intake was significantly less in individuals with tinnitus who were middle-aged (ages 51–55 and 56–60 years, $P = 0.012$ and $P = 0.020$, respectively). Less intake of water, protein, and vitamin B₃ were associated with tinnitus-related annoyance ($P = 0.038$, $P = 0.009$, and $P = 0.005$, respectively). Prevalence of annoyance was significantly associated with less water intake in younger ages (age 45–55 years) but with less protein and vitamin B₃ intake in older ages (age 66–80 years).

Conclusion. Reduced intake of vitamin B₂ and B₃, water, and protein may be associated with tinnitus and tinnitus-related annoyance, and further studies regarding the importance of adequate nutritional intake in the tinnitus management need to be performed.

Keywords. Tinnitus; Riboflavin; Niacinamide; Nutritional Status

INTRODUCTION

Tinnitus is the perception of sounds that occurs in the absence of external acoustic stimulus [1]. Because tinnitus is more com-

mon during old age, prevalence rates of tinnitus have increased during last decades because people now live longer and society has a greater elderly population than before [2]. Tinnitus affects approximately 15% of the total population in Europe and the United States and more than a third of the population older than aged 65 years [3]. In addition, a recent study revealed that considerable amount of children and adolescents also experience tinnitus; this indicates that aging cannot explain the entire mechanism of tinnitus development [4]. Tinnitus can negatively influence health-related quality of life, including self-care, usual activities, subjective discomfort, anxiety, and depression [5].

Although the prevalence of tinnitus and socioeconomic bur-

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Corresponding author: **Young Ho Kim**
Department of Otorhinolaryngology-Head and Neck Surgery, SMG-SNU Boramae Medical Center, Seoul National University College of Medicine, 20 Boramae-ro 5-gil, Dongjak-gu, Seoul 07061, Korea
Tel: +82-2-870-2442, Fax: +82-2-870-3863
E-mail: yhkiment@gmail.com

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den of tinnitus has increased, the mechanism of tinnitus is still unclear and debatable [6]. Although loss of normal auditory input and subsequent compensation of auditory pathway is the assumed mechanism of tinnitus, many with tinnitus patients have normal hearing and report no hearing loss [7]. Because the mechanism of tinnitus is not established, the treatment outcome is not fully satisfactory although various approaches have been tried. Counselling, cognitive-behavioral therapy, tinnitus retraining therapy, hearing aids, auditory perceptual training, and pharmacological treatment have been used to treat tinnitus, but none of those approaches can cure all of tinnitus patients [8].

Several studies have evaluated the effect of nutritional supplementation on tinnitus perception and treatment. McCormack et al. [9] analyzed the relation between several food types and tinnitus development, and Spankovich et al. [10], recently reported that subjects with healthier diet showed lower incidence of tinnitus than those with poorer diet. However, those previous studies did not clarify which dietary elements are associated with development of tinnitus. The following supplements are frequently recommended for tinnitus patients: iron, zinc, magnesium, phosphorus, potassium, vitamin B₆, vitamin B₁₂, vitamin A, vitamin C, and vitamin E. However, the evidence supporting the use of vitamins for the treatment of tinnitus has primarily been anecdotal and empirical [11]. Moreover, several studies fail to support a positive role of supplementation in tinnitus treatment [12]. In this study, we aimed to evaluate the associations between nutritional intake and tinnitus in a large cross-sectional cohort.

MATERIALS AND METHODS

Data collection

This study analyzed data of the sixth Korea National Health and Nutrition Examination Survey (KNHANES) collected from 2013 to 2015. The KNHANES is an ongoing nationwide survey of noninstitutionalized population of South Korea with a high level of standardization and quality control. The data were collected and managed by the Centers for Disease Control and Prevention of Korea. Each year, a panel selected 192 enumeration districts and 20 households in each district sampled to re-

flect the entire Korean population. The sampling was weighted by statisticians by adjusting the poststratification, nonresponse rate and extreme values. These samples represent the civilian, noninstitutionalized South Korean population using stratified, multistage clustered sampling based on national census data by the National Statistical Office. The study was conducted in accordance with the ethical principles stated in the Declaration of Helsinki. The study protocol was reviewed and approved by the Ethics Committee of the Korea University Medical Center. Written informed consent was obtained prior to the survey from all participants.

Survey and study population

The presence of tinnitus was based on responses to the following question: "Have you heard any ringing, buzzing, roaring, or hissing sounds without an external acoustic source in the past year?" The response options were "Yes," "No," and "I cannot remember." The participants who answered "I cannot remember." were excluded. Then, the participants were asked about the severity of the tinnitus: "Do these sounds bother you?" The response options were "No," "A little annoying," and "Very annoying and difficult to sleep." Responses of "a little annoying" (n=432) and "very annoying" (n=45) were combined as one category of "tinnitus-related annoyance" because those are different from tinnitus without annoying in that tinnitus with an-

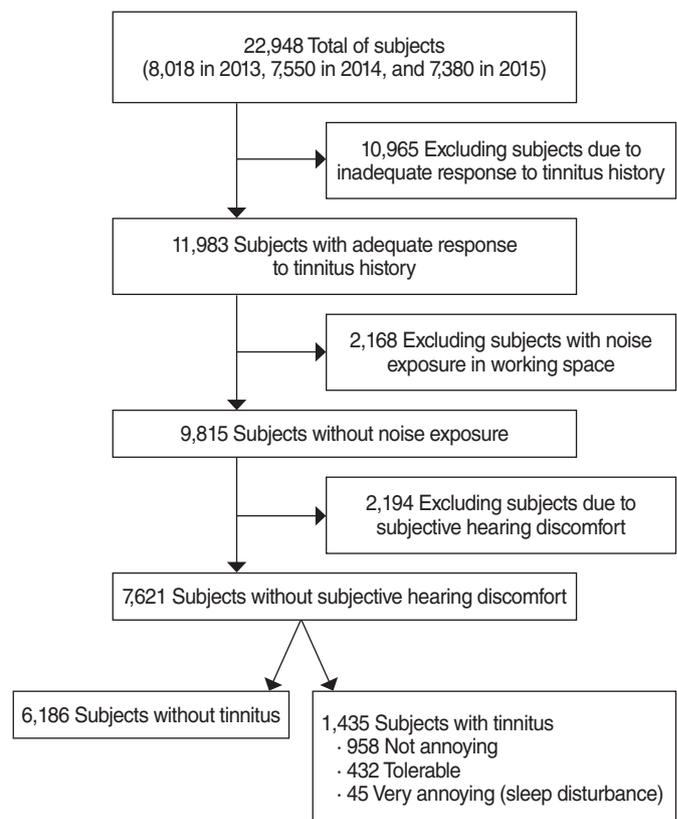


Fig. 1. Study population. Flow diagram of exclusions.

HIGHLIGHTS

- Our study demonstrated that lower body mass index and less vitamin B₂ were significantly associated with tinnitus.
- Vitamin B₃, protein, and water intake were associated with tinnitus-related annoyance.
- Clinicians should try to counsel tinnitus patients to maintain adequate body weight and sufficient nutritional intake, including vitamin B₂, vitamin B₃, water, and protein.

noyance may be more severe and louder and therefore can be notified by subjects and bother daily life occasionally. In addition, individuals with noise exposure were excluded (Fig. 1). Subjective hearing loss was assessed using the question: "Is there any problem with your hearing?" The response options were "No," "A small problem," "A big problem," and "Can't hear anything." Only individuals who reported "no hearing loss" were included.

Among the 22,948 subjects in the dataset, 11,983 subjects with age greater than 40 were included who responded adequately about their subjective tinnitus history. Other exclusion criteria, as above-mentioned: (1) subjects with noise exposure in work place or daily life, (2) subjects reporting subjective hearing loss. Finally, the remaining 7,621 subjects (without noise exposure or subjective hearing loss) were enrolled in this study (Fig. 1).

To analyze the association between nutritional intake and tinnitus (also with tinnitus-related annoyance), age, sex, BMI (kg/m^2), and food and water intake were evaluated by survey of dietary profile. A Survey was performed regarding the intake of 112 foods which are the most frequently consumed by the Korean population. Diet was assessed with a semi-quantitative food-frequency questionnaire and participants answered how often, on average, they had consumed each of the food and dish items listed and what the usual serving size of each item was during the year of the study. For each food, frequency of intake were determined by the responses: "I do not eat that food," "once per month," "2–3 times per month," "once per week," "2–4 times per week," "5–6 times per week," "one a day," "twice per day," and "3 times per day." Nutritional parameters included protein, fat, saturated fatty acid, monounsaturated fatty acid, polyunsaturated fatty acid, cholesterol, carbohydrate, dietary fiber, calcium, phosphorus, iron, sodium, potassium, vitamin A, carotene, retinol, vitamin B₁, vitamin B₂, vitamin B₃, and vitamin C. Age groups were categorized using 5-year intervals: age 40–45, 46–50, 51–55, 56–60, 61–65, 66–70, 71–75, and 76–80 years.

Statistical analysis

Sample weights of each participant, which was reported by KNHANES for each individual based on the complex probability of being selected, were applied to all statistical analyses. After applying the weighted values recommended by KNHANES, the adjusted odds ratios (AOR) were estimated. The associations between the nutritional status and tinnitus were analyzed using uni- and multivariate binary logistic regression analysis. In subgroup analysis, in each age group, the difference in risk factors between individuals with and without tinnitus was analyzed by Student *t*-test. The AOR and 95% confidence interval (CI) were calculated, and *P*-values lower than 0.05 were considered to indicate significance. The results were analyzed statistically using IBM SPSS ver. 20.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Nutritional intake, prevalence of tinnitus, and tinnitus-related annoyance according to age

Median age of included participants was 55.5 years (40–80 years). Total food and water intake decreased with age, and a significant decrease in food intake was observed after age 60 years ($P=0.008$) and in water intake after age 70 years ($P=0.001$). The consumption of all other nutritional substances also decreased with age. Prevalence of tinnitus in subjects with subjective normal hearing was 18.8% (1,435/7,621) in the total cohort. Among those with tinnitus, approximately 66% (958/1,435) reported no annoyance from tinnitus. The prevalence of tinnitus increased with age; however, among individuals with tinnitus, the proportion with tinnitus-related annoyance was similar across age groups ($P=0.493$) (Fig. 2).

Association between intake and tinnitus

Based on univariate analysis, age, sex, BMI, and the intake of most nutritional substances were significantly associated with tinnitus (Table 1). Individuals with tinnitus were significantly older and more often female than individuals without tinnitus ($P<0.001$ and $P<0.001$, respectively). Intake of many nutrients was significantly less in individuals with tinnitus; however, intake of water, dietary fiber, iron, vitamin A, and retinol was not significantly associated with tinnitus ($P=0.594$, $P=0.110$, $P=0.207$, $P=0.095$, and $P=0.811$, respectively). Multivariate analysis revealed that age (OR, 0.989; 95% CI, 0.983 to 0.995), sex ratio (OR, 1.239; 95% CI, 1.081 to 1.421), and BMI (OR, 1.020; 95% CI, 1.001 to 1.040) were significantly associated with tinnitus ($P<0.001$, $P=0.002$, and $P=0.041$, respectively). Among nutritional substances, only less vitamin B₂ intake was independently associated with tinnitus (OR, 1.253; 95% CI, 1.049 to 1.496; $P=0.013$) (Table 1). In all age groups, less intake of vitamin B₂ was observed in individuals with tinnitus. Among those in the age groups 51–55 and 56–60 years, vitamin B₂ in-

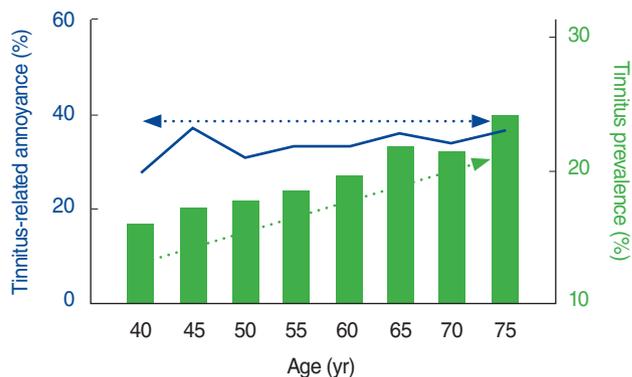


Fig. 2. Prevalence of tinnitus and proportion of annoying tinnitus according to age groups. Prevalence of tinnitus increases with age, whereas the proportion of tinnitus-related annoyance among individuals with tinnitus is not significantly affected by age.

Table 1. Association of dietary intake with tinnitus according to univariate and multivariate binary logistic regression

Variable	Univariate analysis					Multivariate analysis		
	Tinnitus (+)	Tinnitus (-)	AOR	95% CI	P-value	AOR	95% CI	P-value
Age (yr)	59±12	57±11	0.986	0.981–0.991	<0.001	0.989	0.983–0.995	<0.001
Sex ratio (male:female)	1:1.82	1:1.46	1.246	1.106–1.404	<0.001	1.239	1.081–1.421	0.002
BMI (kg/m ²)	23.83±3.22	24.05±3.18	1.022	1.003–1.040	0.021	1.020	1.001–1.040	0.041
Water intake (cup)	4.68±3.00	5.03±19.11	1.003	0.992–1.014	0.594	-	-	-
Food intake (g)	1,462.5±737.8	1,560.4±848.8	1.000	1.000–1.000	<0.001	1.000	1.000–1.000	0.357
Carbohydrate intake (g)	191.87±213.31	311.82±123.73	1.001	1.000–1.001	0.041	1.000	0.999–1.001	0.981
Protein intake (g)	62.39±34.53	65.63±45.14	1.002	1.001–1.004	0.008	0.999	0.994–1.005	0.781
Fat intake (g)	34.81±27.68	37.49±31.67	1.003	1.001–1.005	0.004	1.006	0.986–1.027	0.543
Saturated fatty acid intake (g)	9.56±8.22	19.38±9.39	1.011	1.004–1.018	0.004	1.001	0.972–1.031	0.935
MUFA intake (g)	10.75±10.37	11.58±10.99	1.008	1.002–10.14	0.013	0.985	0.957–1.014	0.311
PUFA intake (g)	9.20±7.89	9.81±9.83	1.008	1.001–1.016	0.033	0.994	0.970–1.018	0.629
Cholesterol intake (mg)	191.87±213.31	209.90±242.95	1.000	1.000–1.001	0.013	1.000	0.999–1.001	0.379
Dietary fiber intake (g)	25.14±13.88	25.84±14.24	1.004	0.999–1.008	0.110	-	-	-
Calcium intake (mg)	458.20±267.31	486.38±312.72	1.000	1.000–1.001	0.003	1.000	1.000–1.000	0.656
Phosphorus intake (mg)	1,008.49±495.49	1,054.12±589.17	1.000	1.000–1.000	0.008	1.000	0.999–1.000	0.362
Iron intake (mg)	17.11±11.30	17.96±23.91	1.003	0.998–1.008	0.207	-	-	-
Sodium intake (mg)	3,509.03±2,359.71	3,747.37±3,396.64	1.000	1.000–1.000	0.007	1.000	1.000–1.000	0.803
Potassium intake (mg)	3,029.53±1,685.27	3,135.94±3,396.64	1.000	1.000–1.000	0.044	1.000	1.000–1.000	0.130
Vitamin A intake (µg)	699.27±992.38	749.89±981.25	1.000	1.000–1.000	0.095	-	-	-
Carotene intake (µg)	3,482.57±5,337.87	3,812.41±5,311.78	1.000	1.000–1.000	0.045	1.000	1.000–1.000	0.368
Retinol intake (µg)	101.47±431.25	98.62±377.42	1.000	1.000–1.000	0.811	-	-	-
Vitamin B ₁ intake (µg)	1.88±0.90	1.97±0.96	1.101	1.030–1.176	0.005	0.985	0.872–1.112	0.805
Vitamin B ₂ intake (mg)	1.17±0.68	1.28±0.84	1.216	1.115–1.326	<0.001	1.253	1.049–1.496	0.013
Vitamin B ₃ intake (mg)	14.74±8.32	15.71±11.56	1.012	1.005–1.019	0.001	1.005	0.989–1.020	0.561
Vitamin C intake (mg)	107.96±115.63	117.52±133.32	1.001	1.000–1.001	0.017	1.001	1.000–1.001	0.105

Values are presented as mean±standard deviation.

AOR, adjusted odds ratio; CI, confidence interval; BMI, body mass index; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid.

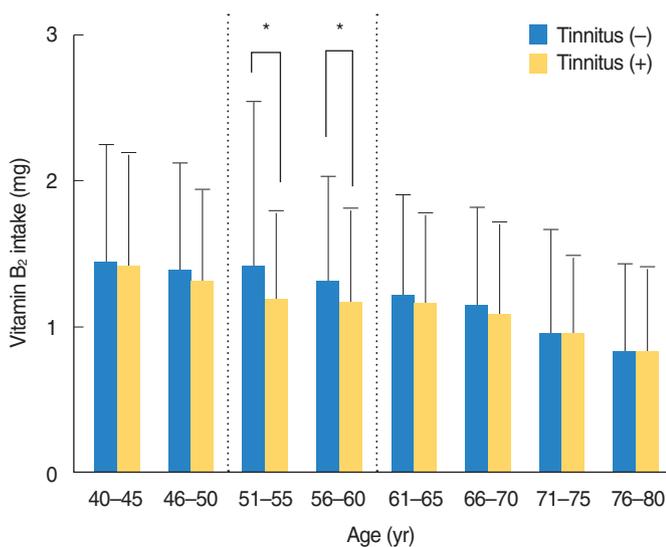


Fig. 3. Association between tinnitus and vitamin B₂ intake by age groups. Vitamin B₂ intake is less in individuals with tinnitus at all ages; this difference was significant among those age 51–60 years. **P*<0.05.

take was significantly less in those with tinnitus than without tinnitus (*P*<0.001 for age 51–55 and *P*=0.013 for age 56–60) (Fig. 3).

Association between nutritional intake and tinnitus-related annoyance

Among the individuals with tinnitus, tinnitus-related annoyance was associated with less intake of water (OR, 0.958; 95% CI, 0.919 to 0.980), protein (OR, 0.995; 95% CI, 0.992 to 0.999), and vitamin B₃ (OR, 0.979; 95% CI, 0.964 to 0.993) based on univariate analysis (*P*=0.038, *P*=0.009, and *P*=0.005, respectively). However, based on multivariate analysis, no nutrient was significantly associated with tinnitus-related annoyance (Table 2). In all age groups, less intake of water and protein was observed in individuals suffering tinnitus-related annoyance. This difference was significant among those age 45–55 years (*P*=0.018 for age 45–50 and *P*=0.008 for age 51–55) for water intake and age 66–80 years (*P*=0.027 for age 66–70, *P*=0.014 for age 71–75, and *P*=0.026 for age 76–80) (Fig. 4). Less intake of vitamin B₃ was observed in those reporting tinnitus-related annoyance across all age groups; this difference was significant only in those aged 66–70 and 76–80 years (*P*=0.002 and *P*=0.029, respec-

Table 2. Association between dietary intake and tinnitus-related annoyance according to binary logistic regression

Variable	Univariate analysis				
	Annoyance (+) (n=477)	Annoyance (-) (n=958)	AOR	95% CI	P-value
Age (yr)	60±12	58±12	1.008	0.999–1.018	0.079
Sex ratio (male:female)	1:2.10	1:1.70	0.813	0.645–1.026	0.082
BMI (kg/m ²)	23.80±3.03	23.84±3.31	1.003	0.992–1.014	0.594
Water intake (cup)	4.43±2.80	4.80±3.06	0.958	0.919–0.998	0.038
Food intake (g)	1,414.20±721.75	1,487.06±745.04	1.000	1.000–1.000	0.092
Carbohydrate intake (g)	300.29±132.13	305.93±118.46	1.000	0.999–1.001	0.434
Protein intake (g)	58.87±31.81	64.19±35.73	0.995	0.992–0.999	0.009
Fat intake (g)	32.87±28.55	35.80±27.19	0.996	0.992–1.000	0.072
Saturated fatty acid intake (g)	8.99±8.17	9.85±8.23	0.987	0.972–1.001	0.074
MUFA intake (g)	10.14±10.01	11.06±10.54	0.991	0.979–1.003	0.131
PUFA intake (g)	8.70±8.36	9.46±7.63	0.987	0.972–1.003	0.101
Cholesterol intake (mg)	178.03±218.25	198.91±210.53	1.000	0.999–1.000	0.096
Dietary fiber intake (g)	24.88±13.56	25.27±14.04	0.998	0.990–1.006	0.624
Calcium intake (mg)	447.74±271.19	463.52±265.31	1.000	0.999–1.000	0.313
Phosphorus intake (mg)	971.10±489.57	1027.52±497.68	1.000	1.000–1.000	0.052
Iron intake (mg)	16.72±9.99	17.31±11.91	0.995	0.985–1.006	0.375
Sodium intake (mg)	3,354.15±2,502.84	3,587.90±2,280.84	1.000	1.000–1.000	0.092
Potassium intake (mg)	2,948.68±1,662.07	3,070.71±1,696.43	1.000	1.000–1.000	0.217
Vitamin A intake (µg)	748.09±1,232.34	674.40±844.13	1.000	1.000–1.000	0.210
Carotene intake (µg)	3,756.89±6,625.12	3,342.86±4,542.52	1.000	1.000–1.000	0.193
Retinol intake (µg)	102.70±541.31	100.85±362.96	1.000	1.000–1.000	0.942
Vitamin B ₁ intake (µg)	1.83±0.89	1.91±0.90	0.903	0.792–1.029	0.126
Vitamin B ₂ intake (mg)	1.13±0.75	1.19±0.64	0.882	0.742–1.048	0.153
Vitamin B ₃ intake (mg)	13.82±7.43	15.21±8.70	0.979	0.964–0.993	0.005
Vitamin C intake (mg)	109.64±117.41	107.10±114.78	1.000	0.999–1.001	0.707

Values are presented as mean ± standard deviation.

AOR, adjusted odds ratio; CI, confidence interval; BMI, body mass index; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid.

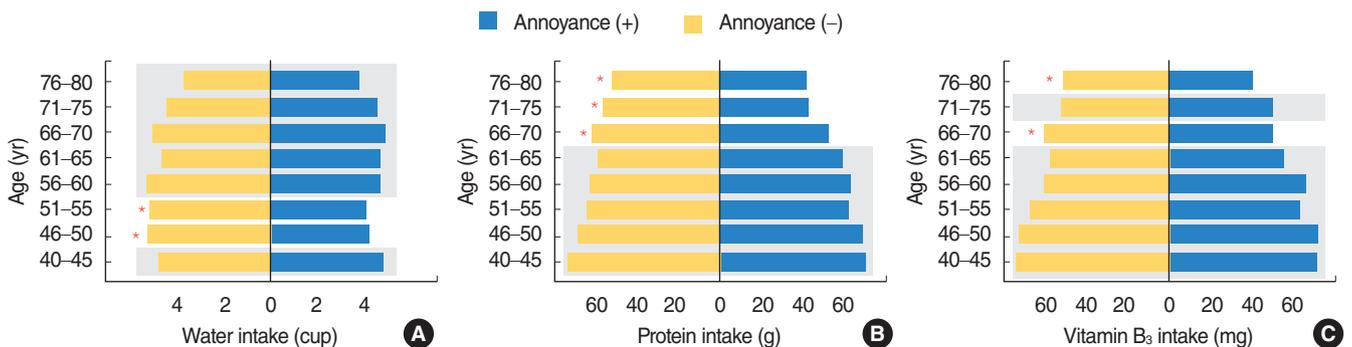


Fig. 4. Association between tinnitus-related annoyance and intake of water, protein, vitamin B₃ intake. (A) Individuals with tinnitus-related annoyance (blue bars) had lower water intake than subjects without annoyance. The association between water intake and annoyance was significant in those middle aged (46–55 years). (B) Protein intake was lower in subjects with tinnitus-related annoyance. The difference was significant in older ages (66–80 years). (C) Vitamin B₃ intake was less in individuals with tinnitus-related annoyance. The difference between individuals with and without annoyance was significant in older ages (66–70 and 76–80 years). Asterisks indicate statistical significance with *P*-value < 0.05 and shadowed areas indicate statistical insignificance.

tively) (Fig. 4). In summary, in middle ages, tinnitus-related annoyance was significantly associated with less intake of water and vitamin B₃ and with less intake of protein in old age.

DISCUSSION

This study indicates that adequate nutritional support may decrease tinnitus and tinnitus-related annoyance. Shargorodsky et al.

[13] reported that in large cohort obesity decreases the risk of tinnitus and higher BMI, $>30 \text{ kg/m}^2$, is associated with decreasing incidence of tinnitus. Likewise, comparisons of individuals with and without tinnitus in large cohorts showed that lower BMI and less nutritional intake are associated with tinnitus. However, conflicting reports observed that high BMI is a risk factor for tinnitus and that BMI was not associated with tinnitus [14], although those conflicting studies evaluated fewer participants. Considering that in cross-sectional cohort studies larger sample size and more diverse comparative parameters assure higher statistical reliability, our results support the hypothesis that higher BMI is associated with prevention of tinnitus and less nutritional intake is associated with development of tinnitus.

A widely accepted assumption of tinnitus pathophysiology is that tinnitus is a consequence of altered patterns of neural activity due to measurable hearing loss [15]. However, this is only one of several explanations because many people with tinnitus have clinically normal hearing and not all those with hearing loss experience tinnitus [16]. Hence, other mechanisms, especially for tinnitus with normal hearing, have been postulated, such as “thalamocortical dysrhythmia model [17].” Tinnitus patients with normal hearing may have limited therapeutic options because they cannot have benefit from masking tinnitus by improving hearing using hearing aids. For this reason, this study focused on the individuals with subjective normal hearing.

Our novel finding was that vitamin B₂ (riboflavin) is the only nutritional parameter independently associated with tinnitus. To the best of our knowledge, this is the first study that observed the association between less vitamin B₂ intake and tinnitus. Because the role of vitamin B₂ in tinnitus is still debatable and most previous reports of this association are clinical observational studies [18], we could not find a report that suggested a mechanism for the protective effect of vitamin B₂ on tinnitus. Vitamin B₂ is a water-soluble vitamin that participates in transferring electrons in mitochondrial oxidation-reduction reactions [19]. In some diseases in which vitamin B₂ is potentially therapeutic, such as mitochondrial encephalopathy, lactic acidosis, and stroke-like episodes, mitochondrial encephalomyopathy, and migraine, the energy metabolism is decreased in mitochondria [20]. Because oxidant production may be increased in tinnitus and patients with tinnitus are exposed to potent oxidative stress [21], vitamin B₂ may prevent tinnitus by enhancing oxidation-reduction reactions. Moreover, there is greater oxidative stress and decreased antioxidant defense in the elderly than younger individuals, which could play an important role in aging [22]. In the older age group, vitamin B₂ intake was not significantly different between individuals with and without tinnitus (Fig. 3). Inappropriate response to oxidative stress in old age may be one of the key mechanisms in the development of tinnitus, and this may explain why our results showed that intake of vitamin B₂ was not significantly different in old age. In contrast, vitamin B₂ status was more critical in younger ages whose de-

fense mechanisms may be stronger than in the elderly; therefore, they may be more susceptible to oxidative stress if proper nutritional support is lacking.

The vitamin B complex is a family of nutrients that are grouped together because of their interrelated functions within human enzyme systems, as well as their distribution in natural food sources [23]. Deficiency in these vitamins has been shown to result in tinnitus [24], and supplementation may improve the symptom. Moreover, vitamin B₂ performs its role as a cofactor for metabolism of other B vitamins [25]. Our large cohort study indicates that vitamin B₂ and B₃ may have critical roles in prevention of tinnitus, perhaps by assisting to maintain functions of the vitamin B complex.

Tinnitus-related annoyance can be more important than tinnitus itself. As an otologist, our treatment target is sometimes limited to the tinnitus patients who suffer from “annoyance” and who cannot tolerate the tinnitus. Intake of water, protein, and vitamin B₃ were possible factors influencing the annoyance, and these associations differed according to age group. Water intake was significantly associated with tinnitus-related annoyance in younger middle age individuals, whereas protein and vitamin B₃ intake were significantly associated with tinnitus-related annoyance in old age.

In general, water intake is inversely associated with active career status (working or studying) [26]. Our study showed that individuals with tinnitus-related annoyance in age group 46–55 have water intake as low as age group 76–80 (Fig. 4). This result may indicate the importance of water intake in the middle age period when most individuals are in active career status. Clinicians need to recognize the importance of water intake as well as other pharmacological treatment and counselling of tinnitus patients who have active careers. In contrast, protein intake decreases with aging [26]. To decrease tinnitus-related annoyance in older ages, elderly tinnitus patients should maintain appropriate protein levels by adequate intake.

Previously, vitamin B₃ (nicotinic acid) has been used to treat tinnitus [27]. Although the exact mechanism that explains how vitamin B₃ alleviates tinnitus is not clear, the vasodilating effect of vitamin B₃ may be responsible for its effect on tinnitus. The assumption that cochlear blood flow is enhanced by vitamin B₃ is based on a study that concluded that nicotinic acid increases intracranial blood flow. Flottorp and Wille [28] treated 22 tinnitus patients with nicotinic acid and relieved the tinnitus in 15 of those patients. Although the success of vitamin B₃ in treating tinnitus is not well established, we think it can ameliorate tinnitus-related annoyance, especially in middle age tinnitus patients.

We postulate that adequate nutritional support, especially vitamin B₂ and B₃, and preventing extremely low BMI may decrease tinnitus in individuals with normal hearing. Although prospective studies regarding nutritional intake are lacking and most evidence supporting treatment using dietary supplementation is anecdotal, a few studies evaluated the nutritional status

(not intake or supplementation) or intake of foods associated with tinnitus [8,29]. Hameed et al. [29] reported that fat and sugar metabolism and abnormal blood level of minerals may be associated with tinnitus. McCormack et al. [9] reported that more fruit and vegetable intake would prevent the development of tinnitus, which may be associated with increased vitamin intake. Our study is the first large cohort study to report the difference of nutritional intake between individuals with and without tinnitus and the possible role of vitamin B₂ and B₃. Although some recent clinical trials of mineral supplementation fail to support a benefit of supplements for tinnitus [30], this study suggests alternative nutritional supplements to manage tinnitus patients. Based on the results of our study, we suggest these nutritional support strategies for tinnitus patients: (1) maintain BMI approaching the upper limit of normal (about 24.9 kg/m²), (2) provide adequate nutritional intake and sufficient water intake, (3) supply dietary supplements that include vitamin B₂ and B₃ ancillary to pharmacologic and behavioral therapy.

Although this study analyzed many factors, its cross-sectional design limited our ability to establish a causal sequence; therefore, we could not rule out the possibility of reverse causality. However, considering that tinnitus generally do not disturb intake of specific nutrition, dietary imbalance which our study demonstrated might have influenced tinnitus development. Because audiometry was not performed and nutrient levels were not measure, most data analyzed in this study was based on the subjective recall of participants; therefore, our study also has potential recall bias. For the better clarification, objective hearing loss should be performed to exclude the most powerful confounding factor, such as high tone hearing loss. In addition, several risk factors, such as comorbidity and medications that can affect the development and aggravation of tinnitus, were not evaluated, which limited our ability to control these potential confounders.

Despite these limitations, this study was based on the large-population cohort and contributes the following benefits. First, the results of this study provide valuable background data useful for planning clinical trials or studies of nutritional support for tinnitus patients. Well-designed protocols that prospectively evaluate important nutritional parameters, such as BMI, blood albumin and vitamin levels, may achieve more robust evidence that supports treating tinnitus using nutritional supplementation. Second, nutritional supplementation, especially vitamin B₂ and B₃, have limited side effects and can be supplied safely to most patients; therefore, clinician can try nutritional support or counselling without much concern for adverse effects. Third, our result should alert clinicians about the importance of nutritional intake in managing tinnitus patients. Nutritional status is often not evaluated by otologists due to limited evidence for treating tinnitus with nutritional supplements. Our results provide valuable background information and suggest one of the easiest ways to manage tinnitus patients with the nutritional intake,

which can be adjunct to conventional pharmacological therapy.

We recognize that vitamin B₂ and B₃ cannot be the sole therapeutic strategy for tinnitus patients. Usually, pharmacological or behavioral therapy should be recommended to patients with tinnitus. Clinicians should also try to counsel such patients to maintain adequate body weight (BMI) and sufficient nutritional intake, including vitamin B₂, vitamin B₃, water, and protein. In addition, clinicians and patients should be careful to check the ingredients of multivitamin supplements for adequate B vitamin content.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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