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Association between depression and tinnitus in a nationally representative sample of US older adults

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Objectives: Few population-based studies examining the association between tinnitus and depression among older adults have been conducted. Therefore, the purpose of this study was to examine the association between tinnitus and depression among a nationally representative sample of US older adults.

Methods: Data from the 2005–2006 National Health and Nutrition Examination Survey was used. 696 older adults (70–85 yr) completed questionnaires on tinnitus and depression, with depression assessed using the Patient Health Questionnaire-9.

Results: After controlling for firearm use, age, gender, race–ethnicity, cardiovascular/stroke history, diabetes, smoking status, body mass index, physical activity, noise exposure and elevated blood pressure, there was a significant positive association (beta coefficient: 1.28, 95% CI: 0.26–2.29, $p = 0.01$) between depression and tinnitus being at least a moderate problem, suggesting that those who perceived their tinnitus to be a moderate problem were more likely to be depressed than those perceiving it to be a small or no problem. Additionally, after adjustments, those who were bothered by tinnitus when going to bed were 3.06 times more likely to be depressed than those who were not bothered by tinnitus when going to bed (OR = 2.44, 95% CI: 1.03–5.76, $p = 0.04$).

Conclusion: These findings suggest that individuals who perceive their tinnitus to be a problem or have problems with tinnitus when going to bed may be in need of intervention to prevent or reduce their depression symptoms so as to ensure that other areas of their life are not negatively influenced.

Keywords: elderly; epidemiology; hearing

Introduction

Tinnitus is a common disorder of the ear that affects 10–15% of adults (Henry, Dennis, & Schechter, 2005). It is characterized as the perception of sound that is heard within the ear in the absence of any external stimulus. This sound has been described as, for example, ringing, roaring, clicking, or buzzing sounds. For some, the symptoms of tinnitus can occur for brief periods that last for at least five minutes, but for many, symptoms may persist the length of the entire day (Dobie, 2003; Meikle, Vernon, & Johnson, 1981).

Due to this constantly perceived sound, tinnitus may interfere with activities of daily living, particularly among those suffering from severe tinnitus. For example, severe tinnitus may negatively influence concentration, sleep, completion of tasks, and social interactions (Dobie, 2003; Holmes & Padgham, 2011). Consequently, some individuals with tinnitus may be more likely to be depressed because of the interference that tinnitus has on these activities of daily living. In a sample of 40 adults with tinnitus, Sullivan et al. (1988) showed that the majority of

participants had reduced activities of daily living as a result of greater depression symptoms.

Although studies have demonstrated a link between tinnitus and depression (Folmer, Griest, Meikle, & Martin, 1999; Halford & Anderson, 1991; Salonen, Johansson, & Joukamaa, 2007; Schonweiler, Neuschulte, & Paar, 1989; Shargorodsky, Curhan, & Farwell, 2010; Weber, Jagsch, & Hallas, 2008), the majority of the studies had relatively small sample sizes or nonpopulation-based samples, which makes it difficult to generalize their findings to larger, more diverse samples. A recent study conducted by Shargorodsky et al. (2010) employed a nationally representative sample from the 1999–2004 National Health and Nutrition Examination Survey (NHANES) and showed that adults with tinnitus were more likely to be depressed. However, this national study was only able to examine the association between tinnitus and depression among individuals aged 20–39 years, as mental health screening was only performed among these age groups in the 1999–2004 cycles. Given that tinnitus frequency is greatest among older adults (Henry et al., 2005), additional national studies are needed, specifically among older

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adults. Additionally, the 1999–2004 NHANES cycles defined tinnitus as *any* ringing, roaring, or buzzing in the ears, which may have misclassified some participants as having tinnitus given that the most recent and accurate definition of tinnitus has changed to symptoms persisting for periods of at least five minutes in duration. To bridge these gaps in the literature, the purpose of this study was to examine the association between tinnitus and depression in a nationally representative sample of older adults using the most recent definition of tinnitus (i.e. lasting at least five minutes in duration).

Methods

Design and participants

This study used data from the 2005–2006 NHANES. Briefly, NHANES employs a representative sample of non-institutionalized US civilians, selected by a complex, multi-stage probability design. The study was approved by the National Center for Health Statistics ethics review board, with informed consent obtained from all participants prior to data collection. Participants were excluded from the study if they were younger than 70 years and had missing depression and tinnitus data. After exclusions, the final sample for the present study included 696 NHANES older adult participants between 70 and 85 years of age.

Measurement of tinnitus

In the 2005–2006 NHANES cycle, participants under 12–19 and 70+ years of age were asked about their tinnitus status. In the present study, analyses were computed on individuals 70+ years of age as depression data was only available for adults in this NHANES cycle. In the 2005–2006 NHANES cycle, participants were asked if in the last 12 months they ever had ringing, roaring, or buzzing in their ears or head that lasted at least five minutes, which herein is referred to as tinnitus. Participants who answered yes to this tinnitus question were asked follow up questions. Specifically, they were asked how long they had been bothered by tinnitus, with possible responses including *less than three months*, *three months to a year*, *1–4 years*, *5–9 years*, and *10 or more years*. Due to the limited observations for these categories, responses were recoded as < 10 years and 10 or more years. Participants were also asked if they were bothered by tinnitus after listening to loud sounds or loud music, with possible response options being *yes* and *no*. They were also asked if they were bothered by tinnitus when going to sleep, with possible responses including *yes* and *no*. They were asked how much of a problem their tinnitus is, with possible response options including *no problem*, *a small problem*, *a moderate problem*, *a big problem* and a *very big problem*. Given the few observations in the last two categories,

the responses for this question were recoded as *no problem*, *a small problem* and a *moderate or more problem*.

Measurement of depression status

At the mobile examination center (MEC), participants completed the Patient Health Questionnaire-9 (PHQ-9) during the computer-assisted personal interview (Kroenke, Spitzer, & Williams, 2001). Sample items from this questionnaire include, ‘over the last two weeks, how often have you been bothered by’: ‘feeling down, depressed or hopeless’, ‘feeling tired or having little energy’, and ‘trouble concentrating on things, such as reading the newspaper or watching television.’ For each question, participants responded using a four-point Likert scale, with responses including *not at all* (0), *several days* (1), *more than half the days* (2), and *nearly every day* (3). Items were summed, with higher scores indicating greater severity of depression. Depression severity was defined by using the following established cut-points from the total PHQ-9 score: no depression (0–4), mild depression (5–9), moderate depression (10–14), moderately severe depression (15–19), and severe depression (20–27) (Kroenke et al., 2001). For the analyses presented herein, we defined depression status as *no depression symptoms* (0–4) and *some depression symptoms* (≥ 5), as few participants were categorized as having moderate depression, moderately severe depression and severe depression. The PHQ-9 has demonstrated evidence of reliability and validity, with Cronbach’s alpha ranging from 0.86—to 0.89 and a 48-hour test-retest correlation coefficient of 0.84 (Kroenke et al., 2001). In the present sample, internal consistency of this questionnaire, as measured by Cronbach’s alpha, was acceptable at 0.72.

Measurement of covariates

Information about age, gender, race–ethnicity, whether they ever used firearms, had a job where they were exposed to loud noise for five or more hours a week, and whether they were ever exposed to loud noise for five or more hours a week outside of their job were obtained from a questionnaire. Additionally, participants were asked if they have ever been told by a doctor or health professional that they had diabetes or sugar diabetes, coronary heart disease, or a stroke. Participants were asked if they, in the last 30 days, engaged in moderate or vigorous physical activity for at least 10 minutes.

During examination at the MEC, body mass index (BMI) was calculated from measured weight and height (weight in kilograms divided by the square of height in meters). After resting quietly for five minutes, three or more measures were obtained. The average of the obtained systolic and diastolic measurements was used. Elevated blood pressure was defined as systolic blood

pressure greater than or equal to 140 mmHg or diastolic blood pressure greater than or equal to 90 mmHg or taking blood pressure lowering medication. Lastly, as a marker of active smoking status or as an index of environmental exposure to tobacco (i.e. passive smoking), serum cotinine was measured. Serum cotinine was measured by an isotope dilution high-performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry.

Data analysis

Using STATA (version 12.0) and to account for the complex survey designed used in NHANES, all statistical analyses included the use of appropriate sample weights, clustering, and primary sampling unit variables. Mean depression scores were calculated across tinnitus, duration of tinnitus, presence of tinnitus after loud sounds, and severity of tinnitus (i.e. how much of a problem tinnitus is). An adjusted Wald test was used to see if there was a significant difference in depression scores across these variables. Among the significant variables, a multivariate linear regression was used to examine the association between depression and the tinnitus-related variables.

A design-based category ratio test was used to determine whether there was an association between the tinnitus variables and depression when dichotomized as *no depression* and *some depression*. Among the significant tinnitus-related variables or those that indicate a trend, a multivariate logistic regression was used to examine the association between the dichotomous depression variable and the tinnitus-related variables. All multivariate regression models controlled for the following variables: ever used firearms, age, gender, race-ethnicity, cardiovascular/stroke history, diabetes, smoking status (as measured cotinine concentration), body mass index, physical activity, noise exposure at job and outside of job, and elevated blood pressure.

Results

Characteristics of the analyzed sample are displayed in Table 1. The weighted percent of participants having tinnitus and some depression symptoms were 23.9% and 17.7%, respectively. Depression scores across tinnitus status, duration of tinnitus, tinnitus after loud sounds, and tinnitus when going to bed are presented in Table 2. With respect to how much of a problem tinnitus was, participants who perceived their tinnitus to be at least a moderate problem (3.0 ± 0.6) reported higher depression scores than those perceiving it to be a small problem (2.2 ± 0.2) or no problem at all (1.8 ± 0.4) ($p = 0.01$).

Results from the multivariate linear and logistic regressions are shown in Table 3. In the linear regression analysis, and after controlling for firearm use, age, gender, race-ethnicity, cardiovascular/stroke history, diabetes,

Table 1. Characteristics (mean/proportion [standard error]) of the analyzed sample.

| Variable | |
|--|-------------|
| <i>N</i> | 696 |
| Age (yr) | 76.9 (0.2) |
| BMI (kg/m ²) | 27.5 (0.3) |
| Weight (kg) | 74.9 (0.9) |
| Height (cm) | 164.8 (0.4) |
| % Male | 42.4 (1.4) |
| Race-ethnicity | |
| % Mexican American | 3.1 (0.6) |
| % Other Hispanic | 0.6 (0.3) |
| % Non-Hispanic White | 87.8 (2.2) |
| % Non-Hispanic Black | 7.5 (1.8) |
| % Other race – including multi-racial | 0.8 (0.4) |
| % Diabetes | 16.5 (1.3) |
| % Cardiovascular disease or stroke | 20.7 (1.8) |
| Mean systolic blood pressure (mmHg) | 137.3 (0.8) |
| Mean diastolic blood pressure (mmHg) | 62.8 (0.8) |
| % Elevated blood pressure | 70.7 (1.1) |
| % Engaging in moderate-to-vigorous physical activity | 48.9 (3.3) |
| % Job exposure to loud noise | 35.3 (1.4) |
| % Loud noise exposure for 5+ hours/week | 14.2 (1.4) |
| % Used firearms | 38.7 (1.9) |
| Cotinine (ng/mL) | 24.8 (3.2) |
| Depression (range = 0–17) | 2.26 (0.1) |
| % With some depression | 17.7 (1.9) |
| % Tinnitus | 23.9 (2.0) |

Table 2. Depression (mean [standard error]) score across tinnitus-related variables.

| Variable | Depression score | <i>p</i> -Value |
|--|------------------|-----------------|
| Tinnitus | | 0.80 |
| With tinnitus (<i>n</i> = 158) | 2.3 (0.3) | |
| Without tinnitus (<i>n</i> = 538) | 2.2 (0.1) | |
| Duration of tinnitus | | 0.05 |
| < 10 years (<i>n</i> = 86) | 2.6 (0.4) | |
| 10+ years (<i>n</i> = 71) | 2.0 (0.4) | |
| Tinnitus after loud sounds | | 0.84 |
| Bothered with tinnitus after loud sounds (<i>n</i> = 12) | 2.1 (0.7) | |
| Not bothered with tinnitus after loud sounds (<i>n</i> = 146) | 2.3 (0.4) | |
| Tinnitus when going to bed | | 0.14 |
| Bothered with tinnitus when going to bed (<i>n</i> = 46) | 2.9 (0.7) | |
| Not bothered with tinnitus when going to bed (<i>n</i> = 112) | 2.0 (0.2) | |
| How much of a problem is tinnitus | | 0.01 |
| No problem (<i>n</i> = 47) | 1.8 (0.4) | |
| A small problem (<i>n</i> = 67) | 2.2 (0.2) | |
| A moderate or more problem (<i>n</i> = 44) | 3.0 (0.6) | |

Table 3. Multivariate linear and logistic regression examining the association between depression and tinnitus-related variables.

| Variable | Beta coefficient/ odds ratio (95% CI) | <i>p</i> -Value |
|--|---|-----------------|
| Linear Regression Models | | |
| Duration of tinnitus (<i>n</i> = 141) | | |
| Less than 10 years | Reference | |
| 10+ years | -0.61 (-1.48 to 0.26) | 0.15 |
| How much of a problem tinnitus is (<i>n</i> = 142) | | |
| No problem | Reference | |
| A small problem | 0.18 (-0.65 to 1.02) | 0.64 |
| A moderate or more problem | 1.28 (0.26–2.29) | 0.01 |
| Logistic regression | | |
| Tinnitus when going to bed (<i>n</i> = 142) | | |
| No | Reference | |
| Yes | 2.44 (1.03–5.76) | 0.04 |

smoking status, body mass index, physical activity, noise exposure and elevated blood pressure, there was a significant positive association (beta coefficient: 1.28, 95% CI: 0.26–2.29, $p = 0.01$) between depression and tinnitus being at least a moderate problem, suggesting that those who perceived their tinnitus to be a moderate problem were more likely to be depressed than those perceiving it to be a small or no problem. In the logistic regression, and after adjustments, those who were bothered by tinnitus when going to bed were 2.44 times more likely to be depressed than those who were not bothered by tinnitus when going to bed (OR = 2.44, 95% CI: 1.03–5.76, $p = 0.04$).

Discussion

These findings show that among older US adults, those who perceive tinnitus to be a problem and those who are bothered with tinnitus when going to bed are more likely to have depression symptoms. Although not measured in the present study, not only may tinnitus at night be associated with depression symptoms, but it may also negatively influence sleep quality. This is particularly concerning as sleep deprivation or disrupted sleep may further increase depression symptoms (Sigurdson & Ayas, 2007), with increased depression symptoms possibly reducing an individual's ability to cope with tinnitus. Additionally, there was a trend toward significance ($p = 0.05$), with those having tinnitus for the longest duration (i.e. 10+ years) reporting the lowest depression score, suggesting their ability to develop coping strategies over time. Taken together, these findings suggest that individuals with tinnitus, particularly those recently experiencing tinnitus symptoms, may be in need of intervention to prevent or

reduce their depression symptoms so as to ensure that other areas of their life are not negatively influenced. Potential evidenced-based strategies among this population to help treat tinnitus, and ultimately depression, include cognitive behavioral treatment. Additionally, recent research (Loprinzi, Lee, Gilham, & Cardinal, In Press) indicates that possibly through increased blood flow and attenuation of spontaneous neural activity within the cochlea, physical activity may serve as an inexpensive method to prevent and/or treat tinnitus, as well as depression (Dunn, Trivedi, & O'Neal, 2001). Given the cross-sectional study design, future prospective studies employing a nationally representative sample of older adults are needed. Additionally, such studies are also needed to determine whether tinnitus causes depression, whether depression exacerbates tinnitus symptoms (Baguley, 2002), or whether the association between tinnitus and depression is bidirectional. Also, investigations examining whether tinnitus causes a delay in falling asleep would offer important insights in future studies.

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