Prevalence of and Risk Factors for Tinnitus and Tinnitus-Related Handicap in a College-Aged Population

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Objective: Tinnitus is a common otological condition that affects almost 10% of US adults. Research suggests that college students are vulnerable to tinnitus and hearing loss as they are exposed to traumatic levels of noise on a regular basis. Tinnitus and its influence in daily living continue to be underappreciated in the college-aged population. Therefore, the objective for the present study was to analyze prevalence and associated risk factors of tinnitus and tinnitus-related handicap in a sample of college-aged students.

Design: A survey was administered to 678 students aged 18–30 years in a cross-section of randomly selected university classes. The survey was adopted from the National Health and Nutrition Examination Survey (2010). It inquired about demographic details, medical and audiological history, routine noise exposure, smoking, sound level tolerance, tinnitus, and tinnitus-related handicap in daily living. Tinnitus-related handicap was assessed by the Tinnitus Handicap Inventory (THI). Participants were divided into four groups: chronic tinnitus (bothersome tinnitus for >1 year), acute tinnitus (bothersome tinnitus for ≤1 year), subacute tinnitus (at least one experience of tinnitus in a lifetime), and no tinnitus (no experience of tinnitus in a lifetime).

Results: The prevalence of chronic, acute, subacute, and no tinnitus was 8.4%, 13.0%, 37.9%, and 40.7% respectively. Almost 9% of subjects with any form of tinnitus reported more than a slight tinnitus-related handicap (i.e., THI score ≥18). A multinomial regression analysis revealed that individuals with high noise exposure, high sound level tolerance score, recurring ear infections, and self-reported hearing loss had high odds of chronic tinnitus. Females showed higher prevalence of acute tinnitus than males. Individuals with European American ethnicity and smoking history showed high odds of reporting subacute tinnitus. Almost 10% of the subjects reported that they were music students. The prevalence of chronic, acute, and subacute tinnitus was 11.3%, 22.5%, and 32.4%, respectively, for musicians, which was significantly higher than that for nonmusicians. Music exposure, firearm noise exposure, and occupational noise exposure were significantly correlated with tinnitus. Temporal characteristics of tinnitus, self-reported tinnitus loudness, and sound level tolerance were identified as major predictors for the overall THI score.

Conclusions: Despite the reluctance to complain about tinnitus, a substantial portion of college-aged individuals reported tinnitus experience and its adverse influence in daily living. It was concluded that environmental and health-related factors can trigger tinnitus perception, while self-reported psychoacoustic descriptors of tinnitus may explain perceived tinnitus-related handicap in daily living by college-aged individuals. Future research is required to explore effects of tinnitus on educational achievements, social interaction, and vocational aspects of college students.

Key Words: Hyperacusis, Tinnitus, Tinnitus annoyance, Tinnitus loudness, Tinnitus-related handicap, Sound level tolerance.

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INTRODUCTION

Tinnitus is derived from the Latin word *tinnire* meaning "to ring"; it is a common otological condition defined as a ringing, buzzing, roaring, or hissing sound in the absence of an external acoustic source (Shetye & Kennedy 2010). Tinnitus is often accompanied by hearing loss and hyperacusis (Nelson & Chen 2004). Tinnitus is usually subjective; it is perceived only by the patient, and therefore, diagnosis, monitoring, and treatment efficacy rely mostly on self-report (Savastano et al. 2009; Shargorodsky et al. 2010).

Approximately 17% of the population experiences bothersome tinnitus, and 20% of those cases suffers from its severe manifestation (Hazell et al. 1985; Jastreboff 1990; Steinmetz et al. 2009). Patients with tinnitus often complain of tinnitus-related disturbance in daily living. Complaints include sleep deprivation, work hindrance, impaired thought processing, poor concentration, impaired emotional stability, and increased risk of depression, anxiety, and insomnia (Tyler & Baker 1983; Schleuning 1991; Folmer et al. 1999; Folmer & Griest 2000; Crocetti et al. 2009). Elderly patients frequently report tinnitus-related insomnia symptoms such as difficulty maintaining sleep, difficulty falling asleep, daytime sleepiness, early morning wakefulness, and nonrestorative sleep, which may lead to poor quality of life (Asplund 2003; Nondahl et al. 2007; Lasisi & Gureje 2011; Izuhara et al. 2013).

Research on the auditory lifestyle of college-aged young adults showed that almost 90% of young adults listened to music on a regular basis, with 26% listening to music for more than 3 hours per day, and 48% reporting that their typical listening level was at a high or near-to-maximum volume (Vogel et al. 2009, 2014; Breinbauer et al. 2012). Almost 50% were exposed to potentially harmful music, 44% used noisy equipment without hearing protection, and almost 29% of them worked in a noisy environment, suggesting that the population might be susceptible to hearing loss and tinnitus (Rawool & Colligon-Wayne 2008).

The estimated tinnitus prevalence is around 7.5% in children and adolescents, and it rises to 9.6% in adults (Mahboubi et al. 2013; Bhatt et al. 2016a). Despite a relatively high prevalence in young adults, tinnitus continues to be underappreciated in this population. Youths are able to describe tinnitus when they are questioned, but they are not likely to proactively complain about what they commonly consider normal (Savastano et al. 2009). In other instances, adults may underestimate their complaints (Baguley & McFerran 1999). Tinnitus may cause anxiety, depression, shorter sleep duration, and poor quality of life in young adults (Bhatt et al. 2017), which may lead to reduced ability to perform routine work and subsequently to lower academic performance in a college-aged population (Stallman 2010). It is conceivable that tinnitus may influence activity and

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participation of college-aged students and may subsequently influence their quality of life.

Though the prevalence and risk factors associated with tinnitus are documented for the noninstitutionalized population of US adults, tinnitus and its influence on daily living have not been investigated well in a population of college-aged students. Therefore, the present study had two aims: (1) to investigate prevalence and associated risk factors of tinnitus, and (2) to investigate prevalence and associated risk factors of tinnitus-related handicap in a collage-aged population.

METHODS

Study Design

A cross-sectional survey was conducted among a population of undergraduate and graduate college students aged 18–30 years from the Flagstaff campus of Northern Arizona University. A questionnaire was constructed to assess influence of tinnitus in daily living and to estimate the audiological factors associated with tinnitus. This research was approved by the Institutional Review Board of Northern Arizona University.

Survey Administration

The questionnaire was distributed in randomly selected university classes. The potential participants were asked to fill out the survey and bring their responses back in the subsequent class. These participants did not receive any research incentives. The data collection was performed from September to November 2016. These classes included a total number of 867 students; 678 participants aged 18–30 years filled out the survey, resulting in the response rate of about 78%.

Questionnaire

A questionnaire was constructed to assess audiological factors, tinnitus, and tinnitus-related handicap in daily living (Supplement 1, Supplemental Digital Content 1, http://links.lww.com/EANDH/A384). The survey included assessment of seven areas: demographic details, medical and audiological history, sound level tolerance (SLT), routine acoustic exposure, smoking, tinnitus, and tinnitus-related handicap in daily living.

Demographic Details • Participants were asked about their age, gender, and ethnicity. Response choices for gender included male/female/no disclosure. Response choices for ethnicity included African American, European American, Hispanic, Asian, Native Hawaiian, American Indian, Middle Eastern, Multiracial, or other. Ethnicity was reclassified into a dependent variable with two categories: European American and others (including multiracial).

Medical and Audiological History • The question about medical history was: "What illnesses do you have or have you had? Please check all that apply". Response choices included meningitis, high blood pressure, head injury, diabetes, mumps, heart trouble, malaria, scarlet fever, and other. Medical history was classified into two categories: present medical history or absent medical history. The questions about audiological history asked about hearing loss and middle ear infection. These questions read: "Do you have hearing loss?"; and "Do you have a history of ear infection?". Response choices included Yes, No, Don't know.

Sound Level Tolerance • It was assessed by three questions as follows: "Q.1: Many everyday sounds are unbearably loud to me"; "Q.2: Sounds that others believe are moderately loud are too loud for me"; and "Q.3: I hear very soft sounds that others with normal hearing do not hear". Participants were asked to rate agreement with these sentences on a 0 to 100 scale, where 0 = completely disagree and 100 = completely agree. Ratings of these questions were averaged to quantify SLT on a 0 to 100 scale. These questions were used for estimating hyperacusis in previous studies (Tyler et al. 2003; Gu et al. 2010; Knudson et al. 2014). The third question differed from the first two as it probed perceived loudness of near-threshold sounds. The responses to Q.3 were examined to assure that it did not have undue influence on overall SLT score. Two analyses were performed: (1) the response to the third question was correlated with the average of the responses to the first two questions ($r = 0.3$, $p < 10^{-13}$; as described by Gu et al. 2010); (2) SLT remained a significant predictor for the specific dependent variables listed in Supplement 3, Supplemental Digital Content 3, http://links.lww.com/EANDH/A386, when Q.3 was omitted from SLT calculation. These analyses showed that Q.3 had minimum or no influence on the major findings of the study.

Routine Acoustic Exposure • Acoustic exposure was estimated via a self-report questionnaire developed by Megerson (2010). This survey has been validated to estimate overall acoustic exposure and has been used in previous research to quantify noise exposure in a collage-aged population (Megerson 2010; Stamper & Johnson 2015). It assessed nine specific known areas of high acoustic exposure. They included exposure to six areas of noise exposure: occupational noise, power tools, heavy equipment, commercial sporting or entertainment events, motorized vehicles, small aircraft; and three areas of music exposure: music instrument playing, music listening via personal earphones, and music listening via audio speakers. The survey inquired about frequency of exposure to firearms and firecrackers. It included questions about frequency (i.e., how often) and duration (i.e., how long) of noise exposures. Responses were used to calculate the noise dose for each specific area of high acoustic exposure. Time spent in routine activities performed in quiet environments was calculated by subtracting overall time spent in activities, with high acoustic exposure from 8760 hours (365 days/year × 24 hours/day). Responses were further used to calculate the activity-specific noise dose and overall noise dose, which was reported as $L_{Aeq8760h}$. Here, "L" represents sound pressure level measured in dB, "A" presents use of an A-weighted frequency response; "eq" represents the sound pressure level (in dB) equivalent to the total sound energy over a given period of time; and "8760h" represents the total duration of the noise exposure in hours over 1 year (365 days/year × 24 hours/day). $L_{Aeq8760h}$ was derived from the questionnaire data using the 3-dB exchange rate for calculation of the time/level relation. Further details of the survey can be found in Megerson (2010) and in Stamper and Johnson (2015).

Smoking • This section inquired about smoking with an opening question: "Do you or have you smoked tobacco?". If the participant answered positively to this question, then the follow-up question was: "What types of smoking do you prefer, or have preferred, on a regular basis? (percentage values of all selected choices must add up to 100%)". Smoking history was classified into two categories: present or absent.

Tinnitus • The questions inquiring about tinnitus were adopted from the National Health and Nutrition Examination

Survey (2010) (Center for Disease Control and Prevention, 2011). This section began with the opening question: "In the past 12 months, have you been bothered by ringing, roaring, or buzzing in your ears or head that lasts for 5 minutes or more?". If the participant answered positively to this question, the follow-up question was: "How long have you been bothered by this ringing, roaring, or buzzing in your ears or head?". Response choices for this question included <3 months/3 months to a year/1–4 years/5–9 years/≥10 years/don't know. If the participant answered negatively to the first question, the follow-up question was: "Have you ever experienced ringing, roaring, or buzzing in your ears or head?". Temporal characteristics of tinnitus were categorized into three categories: chronic tinnitus, acute tinnitus, and subacute tinnitus. Chronic tinnitus was defined as a bothersome tinnitus perception for ≥1 year. Acute tinnitus was defined as a bothersome tinnitus perception for <1 year. Subacute tinnitus was defined as at least one episode of tinnitus in an entire life span. No tinnitus was defined as no tinnitus experience in an entire life span. Participants with any form of tinnitus were requested to rate their tinnitus loudness: "On a scale of 0–100, how loud is the sound you hear? (0 = very soft, 100 = painfully loud)". Participants with any form of tinnitus perception were requested to fill out the Tinnitus Handicap Inventory (THI).

Tinnitus-Related Handicap in Daily Living • THI was used to assess tinnitus-related handicap in daily (Newman et al. 1998). It is a 25-item survey, which assesses tinnitus-related handicap on these three subscales: Functional subscale (12 items, e.g., "It is difficult for me to concentrate because of my tinnitus"); Emotional subscale (8 items, e.g., "My tinnitus makes me angry"); and Catastrophic subscale (5 items, e.g., "I feel I can no longer cope with my tinnitus"). Participants were asked to respond to each question by selecting either Yes (4 points), Sometimes (2 points), and No (0 points). The overall THI scores range from 0 to 100, and the degree of perceived tinnitus-related handicap in daily living is categorized as slight (0–16), mild (18–36), moderate (38–56), severe (58–76), and catastrophic (78–100).

Statistical Analysis

Data were analyzed in the SPSS software (version 23.0; SPSS, INC). The prevalence of chronic, acute, subacute, and no tinnitus was calculated among the sample of 678 college-aged participants. Gender, ethnicity, self-reported hearing loss, recurring ear infections, smoking, health history, noise (in $L_{Aeq8760h}$) and SLT were defined as independent variables. Multinomial logistic regression analysis was conducted to calculate the odds ratio of each independent variable after statistical adjustment for all others was made. A logistic regression analysis was performed on 505 participants with complete data for all the dependent variables listed earlier. A linear regression model was used to quantify the relation between the THI score and demographic and audiological variables. This model included the overall THI score as a continuous dependent variable. The analysis was performed using an "enter" method with 10 predictors: gender, ethnicity, self-reported hearing loss, recurring ear infections, smoking, health history, noise (in $L_{Aeq8760h}$), tinnitus loudness, temporal characteristics of tinnitus, and SLT. Pearson's product moment correlation coefficients were computed to examine the relation between temporal characteristics of tinnitus and each specific area of high noise exposure.

RESULTS

Demographic and Audiological Details of the Sample

Tables 1 and 2 present demographic and audiological details of the study sample, respectively. Among 678 participants, 402 (59.3%) participants reported that they experienced tinnitus at least once in their lifetime, and 145 (21.4%) had experienced bothersome tinnitus that lasted for 5 minutes or more in the past 12 months. Analysis of the temporal characteristics of tinnitus revealed that 57 (8.4%) participants reported chronic tinnitus; 88 (13.0%) reported acute tinnitus; and 257 (37.9%) reported subacute tinnitus. Within the study sample, 276 (40.7%) participants reported no tinnitus. Among 402 participants with at least one experience of tinnitus, 96 (23.8%) participants reported that they were bothered by tinnitus only after exposure to loud noise or music. Almost 78% of participants with at least one experience of tinnitus reported that they perceived tinnitus in both ears. Almost 43% of participants with at least one experience of tinnitus considered tinnitus as a substantial problem.

Among 402 participants with at least one experience of tinnitus, 356 (88.5%) individuals reported no tinnitus-related handicap (THI score <16) and 35 (8.7%) individuals reported more than slight tinnitus-related handicap (THI score >18). Among the participants with >18 THI score, 27 individuals reported mild, 7 individuals reported moderate, and one individual reported severe tinnitus-related handicap in daily living.

Results of the Regression Analyses

The multinomial logistic regression analysis revealed that European Americans exhibited higher prevalence of subacute tinnitus than other ethnic groups (odds ratio [OR], 1.958; 95% confidence interval [CI], 1.292–2.968; $p = 0.002$]; smokers showed higher prevalence of subacute tinnitus than nonsmokers (OR, 2.466; 95% CI, 1.343–4.528; $p = 0.004$); and individuals with high noise exposures revealed higher odds

TABLE 1. Demographic and audiological details of the study sample (N = 678)

Variables	Frequency
Gender	
Male	221 (32.6%)
Female	451 (66.5%)
No disclosure	6 (0.9%)
Ethnicity	
Non-Hispanic European American	402 (59.3%)
Non-Hispanic African American	13 (1.9%)
Hispanic	85 (12.5%)
Others or multiracial	178 (26.3%)
Self-reported hearing loss	
Yes	62 (9.1%)
No	614 (90.6%)
Don't know	2 (0.3%)
Recurrent middle ear infection	
Yes	187 (27.6%)
No	419 (61.8%)
Don't know	72 (10.6%)
Smoking	
Yes	119 (17.6%)
No	551 (81.3%)
No disclosure	8 (1.2%)

TABLE 2. Characteristics of tinnitus among the sample of college-aged participants (N = 678)

Variables	Frequency
Any form of tinnitus	
Yes	402 (59.3%)
No	276 (40.7%)
Bothersome tinnitus in the last 12 months	
Yes	145 (21.4%)
No	533 (78.6%)
Temporal characteristics of tinnitus (multiple choice question)	
Chronic tinnitus (duration >1 year)	57 (8.4%)
Acute tinnitus (duration ≤1 year)	88 (13.0%)
Subacute tinnitus (≥1 experience of tinnitus in lifetime)	257 (37.9%)
No tinnitus (no experience of tinnitus in lifetime)	276 (40.7%)
Bother by tinnitus after loud noise/music (multiple choice question)	
Yes	96 (23.8%)
No	234 (58.2%)
Don't know	72 (18.0%)
Affected ear(s) (multiple choice question)	
Right	48 (12.0%)
Left	39 (9.7%)
Both	315 (78.3%)
Tinnitus problem (multiple choice question)	
No problem	230 (57.2%)
A small problem	138 (34.3%)
A moderate problem	32 (8.0%)
A big problem	2 (0.5%)
Type of tinnitus perception (multiple answer question)	
Ringing	288/391 (73.7%)
Buzzing	85/391 (21.7%)
Pulsating	57/391 (14.6%)
Hissing	28/391 (7.2%)
Rushing	20/391 (5.1%)
Roaring	12/391 (3.3%)
Crickets	2/391 (0.5%)
Other	18/391 (4.6%)
Tinnitus Handicap Inventory (overall score)	
Slight	356 (88.5%)
Mild	27 (6.7%)
Moderate	7 (1.7%)
Severe	1 (0.24%)
Catastrophic	0 (0.0%)
Missing	11 (2.7%)

of subacute tinnitus than individuals with low noise exposure (OR, 1.046; 95% CI, 1.002–1.092; $p = 0.04$; Supplement 2 and 3, Supplemental Digital Content 2 and 3, http://links.lww.com/EANDH/A385 and http://links.lww.com/EANDH/A386). The analysis further showed females with lower prevalence of acute tinnitus than males (OR, 0.428; 95% CI, 0.205–0.895; $p = 0.02$); smokers showed higher prevalence of acute tinnitus than nonsmokers (OR, 3.075; 95% CI, 1.365–6.930; $p = 0.007$]; and individuals with high SLT scores revealed higher odds of acute tinnitus than individuals with low SLT scores (OR, 1.019; 95% CI, 1.005–1.033; $p = 0.007$]. Individuals with self-reported hearing loss showed higher prevalence of chronic tinnitus than individuals with no self-reported hearing loss (OR, 4.926; 95% CI, 1.755–13.828; $p = 0.002$); individuals with a history of recurring ear infections showed higher prevalence of chronic tinnitus than their counterparts (OR, 2.427; 95% CI, 1.072–5.496; $p = 0.03$]; individuals with high noise exposure showed greater odds of chronic tinnitus than individuals with low noise exposure (OR, 1.096; 95% CI, 1.016–1.182; $p = 0.018$); and individuals with high SLT scores revealed greater odds of chronic tinnitus than individuals with low SLT scores (OR, 1.035; 95% CI, 1.018–1.053; $p < 0.001$]. Noise exposure was identified as a major predictor for chronic tinnitus. Figure 1 illustrated that individuals with chronic tinnitus reported higher noise exposure scores compared to other experimental groups. An analysis of variance of these scores yielded significant variation among the experimental groups ($F(3, 599) = 5.99$, $p = 0.001$). A post hoc Tukey test resulted in significantly higher noise exposure scores for individuals with chronic tinnitus as compared to other groups ($p < 0.05$), but no significant difference ($p > 0.05$) was obtained in noise exposure scores among the groups with no tinnitus, subacute tinnitus, and acute tinnitus.

A follow-up logistic regression analysis was performed to identify factors associated with any form of tinnitus perception. The analysis revealed lower prevalence of any form of tinnitus for females than for males (OR, 0.642; 95% CI, 0.415–0.992; $p = 0.046$). Individuals with European American ethnicity (OR, 1.915; 95% CI, 1.303–2.815; $p = 0.001$], smokers (OR, 2.481; 95% CI, 1.403–4.387; $p = 0.002$], individuals with high noise exposure (OR, 1.056; 95% CI, 1.015–1.099; $p = 0.007$); and individuals with high SLT scores (OR, 1.011; 95% CI, 1.002–1.021; $p = 0.02$] showed significantly greater odds of reporting any form of tinnitus than their counterparts.

A multiple linear regression model was used to identify predictors for the overall THI score. This analysis was performed on 289 individuals with a complete set of data for all dependent variables. The results revealed significantly higher THI scores for participants with chronic tinnitus compared to participants with acute tinnitus and subacute tinnitus ($\beta = 2.614$, $t(278) = 4.124$, $p < 0.001$). SLT ($\beta = 0.095$, $t(278) = 4.566$, $p < 0.001$) and self-reported tinnitus loudness ($\beta = 0.092$, $t(278) = 4.242$, $p < 0.001$) also were significant predictors for overall THI scores. Further, these predictors explained a proportion of variance in the overall THI scores, adjusted $R^2 = 0.258$, $F(10, 278) = 10.99$, $p < 0.0001$. No other variables included in the analysis showed significant association with the overall THI score. SLT and tinnitus loudness were correlated, $r = 0.299$, $p < 0.001$. Figure 2 shows the relation between experimental groups, self-reported tinnitus loudness, and SLT. Individuals with chronic tinnitus reported higher tinnitus loudness and SLT compared to individuals with acute tinnitus and subacute tinnitus.

Relation Between Tinnitus and Areas of High Noise Exposure

Pearson's product moment correlation coefficients were computed to examine the relation between tinnitus and each specific area of high noise exposure. Tinnitus exhibited a positive correlation to exposure to firearm noise ($r = 0.138$, $p < 0.001$), occupational noise ($r = 0.12$, $p = 0.002$), exposure to commercial sporting or entertainment events ($r = 0.097$, $p = 0.01$), music instrument playing ($r = 0.09$, $p = 0.02$), music listening via personal headphones ($r = 0.092$, $p = 0.017$), and

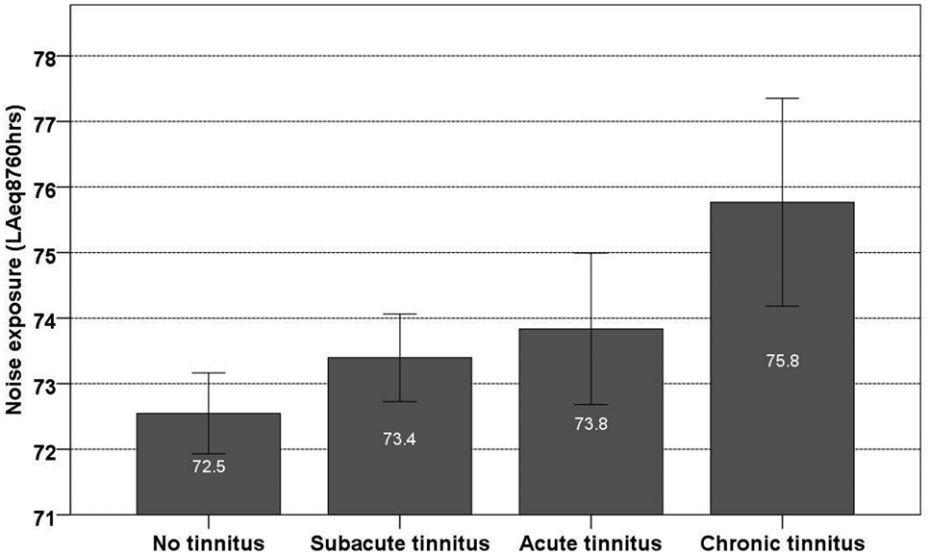

Fig. 1. Average noise exposure score among the participants with no tinnitus, subacute tinnitus, acute tinnitus, and chronic tinnitus. Noise exposure (in LAeq8760hrs) was estimated by a questionnaire developed and validated by Megerson (2010). Error bar indicates 95% of confidence interval.

music listening via audio speakers ($r = 0.116$, $p = 0.003$). Tinnitus and noise dose through routine activities performed in quiet environments were negatively correlated ($r = -0.179$, $p < 0.001$).

Prevalence of Tinnitus in Music Students

Almost 10% of the subjects in the present study reported that they were music students, with most of them reporting that they played musical instruments daily. A statistical analysis was performed to compare the prevalence of tinnitus between musicians and nonmusicians. The prevalence of chronic, acute, and subacute tinnitus was 11.3%, 22.5%, and 32.4%, respectively, for musicians. The prevalence of chronic, acute, and subacute tinnitus was 8.1%, 11.9%, and 38.6%, respectively, for nonmusicians. A χ^2 test showed that the difference between these groups was statistically significant [$X^2(3, N = 678) = 7.91$, $p = 0.048$].

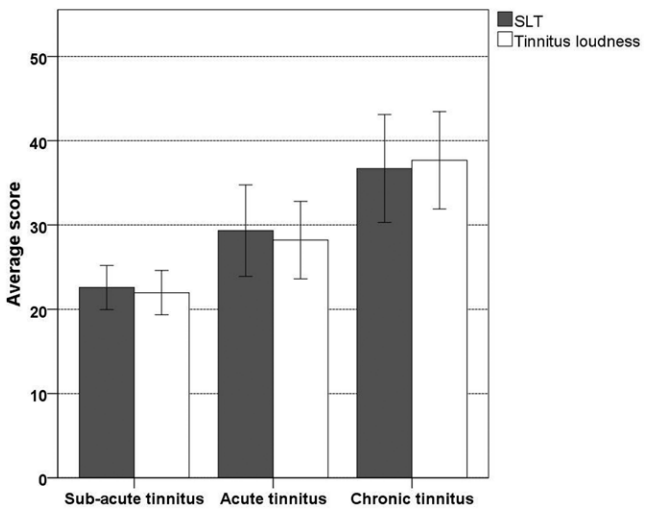

Fig. 2. Average self-reported tinnitus loudness and sound level tolerance (SLT) score (range: 0–100) among participants with subacute, acute, and chronic tinnitus. Error bar indicates 95% of confidence interval.

DISCUSSION

The major finding of the study is that the prevalence of chronic, acute, and subacute tinnitus in the college-aged population was 8.4%, 13.0%, and 37.9%, respectively. Among the participants with any form of tinnitus, almost 9% rated their tinnitus influence in daily living (i.e., THI score >18). Although tinnitus is not considered as debilitating an otological condition in young adults as it is in elderly adults seeking professional intervention, the present study found a substantial portion of college-aged adults reporting adverse effects of tinnitus perception in daily living. The present investigation revealed gender, ethnicity, noise exposure, SLT, history of recurring ear infection, and smoking as major predictors of tinnitus in the college-aged population. These findings aligned with previous epidemiological investigations and further validated the methods used in the present research (Henderson et al. 2011; Mahboubi et al. 2013; Vogel et al. 2014; Shargorodsky et al. 2010; Bhatt et al. 2016a). In addition, SLT, self-reported tinnitus loudness, and temporal characteristics of tinnitus were identified as major predictors of the THI score in the college-aged population.

In the present study, almost 74% of the participants reported ringing, 21.7% reported buzzing, 14.6% reported pulsating, 7.2% reported hissing, 5.1% reported rushing water, and 3.3% reported a roaring type of tinnitus perception (Table 2). This finding is in agreement with a previous report showing that the prevalence of ringing, buzzing, pulsating, heartbeating, and a humming form of tinnitus was 57%, 21%, 22%, 21%, and 14%, respectively (Heller & Bergman 1953; Tucker et al. 2005).

Factors Associated With Tinnitus in a College-Aged Population

The regression analysis revealed that females show a higher prevalence of tinnitus compared to males. This finding is consistent with previous reports (Henderson et al. 2011; Mahboubi et al. 2013; Shargorodsky et al. 2010). A previous study associated rising prevalence of noise-induced hearing loss (NIHL) with lower prevalence of hearing protection use for females compared to males (Henderson et al. 2015). The lower prevalence

of hearing protection use might be a factor in the higher prevalence of tinnitus in females. In addition, subjects with European American ancestry showed higher prevalence of tinnitus compared to other ethnic groups. This observation is consistent with previous investigations (Mahboubi et al. 2013; Shargorodsky et al. 2010; Bhatt & Guthrie, 2017). The prevalence of chronic, acute, and subacute tinnitus in subjects with European American ethnicity was 9.5%, 13.7%, and 42.0%, respectively, in the present study. Thirteen subjects reported African American ethnicity, and none of them reported chronic tinnitus. Almost 13% of the subjects reported Hispanic ethnicity; the prevalence of chronic, acute, and subacute tinnitus was 9.4%, 10.6%, and 41.2%, respectively. Among 178 subjects reporting other and/or multiracial ancestry, the prevalence of chronic, acute, and subacute tinnitus was 6.2%, 12.4%, and 27%, respectively. This evidence suggests that susceptibility to tinnitus might be influenced by ethnicity-related biological variables, which may be influenced by genetic and epigenetic factors.

The relation between smoking and tinnitus has been elusive. In this study, the regression analysis showed that tinnitus was more prevalent in college students who smoked. Previous studies of tinnitus have found higher prevalence of both tinnitus and NIHL in smokers (Paschoa and Azevedo 2009; Henderson et al. 2011; Mahboubi et al. 2013; Shargorodsky et al. 2010; Bhatt & Guthrie, 2017). Smokers showed lower amplitude of otoacoustic emissions and reduced strength of the medial olivocochlear reflex compared to nonsmokers, suggesting that the cochlear mechanism might be vulnerable to smoking-induced damage (Katbamna et al. 2007; Nagaraj 2010). Future research is needed to identify the mechanism underlying the positive relation between tinnitus and smoking.

Noise exposure was identified as a major risk factor for tinnitus. Figure 1 depicts the average noise exposure score among experimental groups. The average score was higher for the chronic tinnitus group compared to the no tinnitus, subacute tinnitus, and acute tinnitus groups. The analysis further revealed three major noise exposure areas associated with tinnitus in young adults: (1) music exposure, (2) firearm noise exposure, and (3) occupational noise exposure. Young adults may be exposed to traumatic sound through personal music players (Breinbauer et al. 2012; Carter et al. 2014; Vogel et al. 2009, 2014). Personal music players can exceed 125 dB SPL at maximum volume settings, and almost 18% of young adults were reported to spontaneously select a listening level above 85 dB (Breinbauer et al. 2012). Recent reports suggest that almost 58% of young adults exceed the 100% daily noise dose through personal music players, particularly in the presence of background noise (Jiang et al. 2016). In the present study, almost 7% of the subjects reported that they typically listen to music at the maximum volume, and almost 42% reported that they typically listen to music at the three-fourth volume control setting, suggesting listening to personal music players might be a major risk factor for tinnitus in young adults.

Frequent exposure to entertainment events such as car/truck races, commercial/high school sporting events, music concerts/dances, and other amplified public announcements was associated with tinnitus. Noise levels at entertainment events often exceed the dose of 100% and subsequently have been associated with temporary threshold shift and temporary level shift (Teie 1998; Carter et al. 2014; Buckey et al. 2015). In the present study, almost 90% of the subjects reported that they never wore hearing protection while attending entertainment events. This observation suggests that noise exposure at entertainment events can insult the auditory system and may induce tinnitus.

A recent study found that college-aged student musicians were exposed to high levels of music on a regular basis, and almost 50% of music students exceeded a 100% dose on a typical college schedule (Washnik et al. 2016). The present study revealed that music instrument playing was associated with tinnitus in young adults. The prevalence of chronic, acute, and subacute tinnitus was 11.3%, 22.5%, and 32.4%, respectively, for musicians, which was higher than that for nonmusicians. Almost 90% of musicians reported that they never wore hearing protection, while almost 10% reported that they sometimes wore hearing protection. None of the music students reported daily use of hearing protection while playing musical instruments.

Firearm noise exposure was associated with tinnitus in the college-aged population. The detrimental effects of impulse noise exposure on the auditory system have been well documented (Hamernik et al. 1984; Starck et al. 2003; Yankaskas. 2013; Xiong et al. 2014; Spankovich et al. 2014). Populations exposed to firearm noise showed higher prevalence of NIHL and tinnitus; this included police officers, industrial workers, and military veterans (Christiansson and Wintzell 1993; Sułkowsk et al. 1999; Job et al. 2004; Theodoroff et al. 2015; Wells et al. 2015). Firearm noise exposure can accelerate age-related hearing loss in young adults (Christiansson and Wintzell 1993). In the present study, almost 23% of the subjects with exposure to firearm noise reported that they never used hearing protection, and almost 19% of them reported that they sometimes wore hearing protection. These results corroborate studies demonstrating that firearm noise exposure may damage auditory mechanisms in ways that trigger tinnitus.

The relation between occupational noise exposure and tinnitus has been studied well in the literature (Axelsson & Prasher 2000; Rubak et al. 2008; Lindblad et al. 2014; Frederiksen et al. 2017), and the present study corroborated the findings that occupational noise exposure is a risk factor for tinnitus in young adults. Almost 15% of the subjects reported occupational noise exposure in the present study. Almost 87% of the subjects with occupational noise exposure reported that they never received training about noise and hearing loss at their workplace. Almost 60% of the subjects with occupational noise exposure reported that they never wore hearing protection at their workplace, and only four individuals reported that they received hearing tests through their job. The lack of hearing conservation strategies used in the workplace might be because of employers' lack of awareness of adverse effects of noise on human health. Another possible explanation is that the noise levels might not be consistently above the noise exposure standards to warrant a hearing conservation program, yet might be severe enough to cause tinnitus in some individuals.

Noise dose through routine activities performed in quiet environments showed a negative correlation with tinnitus. This finding suggested that limited exposure to noisy situations may reduce tinnitus severity. Collectively, the study identified the confluence of audiological, environmental, and health-related risk factors associated with tinnitus in young adults. These results reiterate the importance of implementing hearing conservation education programs at university campuses to prevent tinnitus and hearing loss in young adults.

Factors Associated With Tinnitus-Related Handicap in Daily Living

Although noise exposure was identified as a major risk factor for experiencing tinnitus, it was not associated with the overall THI score. Similarly, gender, ethnicity, history of recurring ear infection, smoking, and SLT were identified as risk factors for experiencing tinnitus, but they were not associated with the overall THI score. This finding signifies that environmental and health-related factors can be major contributors to triggering tinnitus perception, while self-reported psychoacoustic descriptors of tinnitus may explain perceived tinnitus-related handicap in daily living by college-aged individuals. Psychological factors such as depression and anxiety might also contribute to tinnitus-related handicap in daily living (Kehrle et al. 2016).

Previous epidemiological investigation indicated that children and young adults with chronic tinnitus may report tinnitus-related handicap in daily living (Bhatt et al. 2017). In the present study, chronic tinnitus was associated with higher overall THI scores compared to other experimental groups. This finding is supported by a body of research associating chronic tinnitus with depression, anxiety, and insomnia, leading to compromised quality of life in elderly patients (Tyler & Baker, 1983; Davis 1989; Schleuning 1991; Folmer et al. 1999; Folmer & Griest 2000; Holgers & Juul 2006; Aksoy et al. 2007; Crocetti et al. 2009).

A relation between tinnitus loudness and perceived tinnitus-related handicap in daily living is not well established. While previous investigations revealed no association between absolute tinnitus loudness level and tinnitus-related handicap (Baskill & Coles 1999; Folmer et al. 1999; Andersson et al. 2003), self-reported tinnitus loudness and tinnitus-related handicap were moderately correlated in elderly patients (Hiller & Goebel 2007). Hearing loss, presence of neurological diseases, and SLT were other predictors of tinnitus-related handicap in elderly adults (Hiller & Goebel 2007). In the present study, tinnitus loudness and SLT were identified as important predictors for the overall THI score, whereas medical history and self-reported hearing loss showed no association with tinnitus-related handicap in daily living. These results can be attributed to the study population of young adults with no complaint of neurological and otological diseases.

Evidence of Unexplained Variability in Tinnitus Measure: Indication of Genetic Influence?

Recent studies suggest that tinnitus and NIHL can be influenced by genetic factors (Sand et al. 2007; Sand et al. 2010; Sand 2011; Pawelczyk et al. 2012; Sand et al. 2012; Phillips et al. 2015; Bhatt et al. 2016b; Yuce et al. 2016). In the present study, demographic and audiological factors explained the limited variability in tinnitus measures. Almost 3% of variability in the tinnitus measure was exclusively attributable to noise exposure ($r = 0.163$, $p = .001$). Figure 3 shows a scatter plot between the overall THI score and noise exposure. The data illustrate variability in tinnitus measures among college-aged individuals. The figure reveals that some individuals acquire chronic tinnitus and report a high overall THI score despite exposure to low noise, while some individuals acquire no tinnitus (not shown in the figure) despite exposure to high noise. It was hypothesized that individuals with no tinnitus represent a group of "resistant subjects" who did not have a single experience of tinnitus in their lifetime despite exposure to routine noise, while individuals with chronic

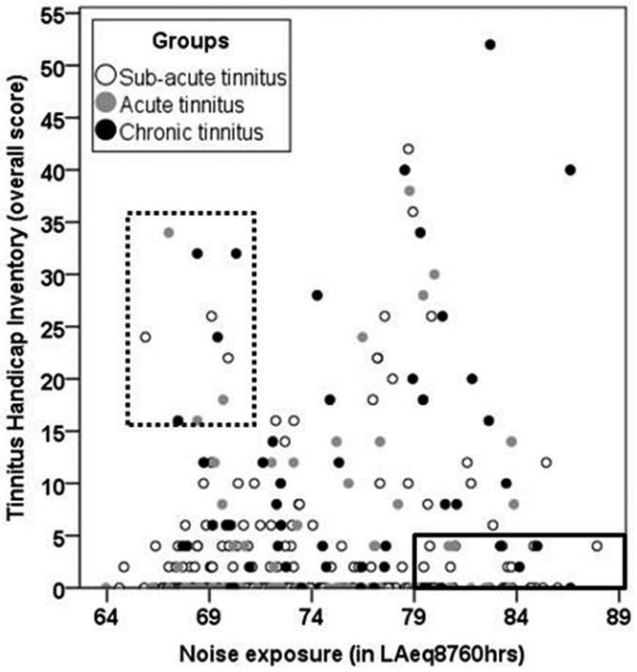

Fig. 3. Scatter plot between the overall Tinnitus Handicap Inventory (THI) score as a measure of perceived tinnitus-related handicap in daily living and noise exposure (in LAeq8760hrs) among participants with subacute, acute, and chronic tinnitus. Data points under the box with solid outline represent a group of subjects exposed to high noise exposure but reported low THI score. Data points under the box with dashed outline represent a group of subjects exposed to low noise exposure but reported high THI score.

tinnitus represent a group of "sensitive subjects" who might be "genetically predisposed" to tinnitus and might have subclinical damage to the auditory system. Subjects with acute and subacute tinnitus may represent a group of subjects with "environmentally induced" tinnitus, which might be related to acute exposure to environmental risk factors (such as noise). The environmentally induced tinnitus might eventually lead to chronic tinnitus in cases with frequent acute exposure to environmental risk factors. These clinical hypotheses may be tested if chronic tinnitus is treated as a phenotype for genetic association analysis.

The college-aged population provides a unique opportunity to investigate genetic association with tinnitus because (1) subjects are exposed to low levels of environmental risk factors, so that inherently vulnerable subjects (i.e., with chronic tinnitus) are likely to be readily distinguished from the subjects with "environmentally induced" tinnitus; (2) age-related confounding variables such as systemic diseases and age-related hearing loss are absent, which will be helpful to delineate psychoacoustic and electrophysiological phenotypic characteristics related to chronic tinnitus; (3) otological diseases which frequently obscure the study of genetic association to tinnitus are absent in this population; and (4) the population is easily accessible for a large sample genetic association study. Future research is needed to investigate genetic factors associated with tinnitus in young adults.

Evidence of Decompensated Tinnitus in Young Adults

Using psychological distress as a comorbid clinical entity, tinnitus has been categorized into two groups: compensated tinnitus and decompensated tinnitus (Stobik et al. 2003). In

compensated tinnitus, auditory perception is normally extinguished through the habituation mechanism involving frontal gyri, cingulate gyrs, and parietal cortices collectively known as a global network workspace (Dehaene & Changeux 2011). The global network workspace neurons typically accumulate information through recurrent top–down/bottom–up loops, where information is not gathered in a single brain center but the information is processed by multiple neural processors and converge into a coherent metastable state (Dehaene et al. 2011). In decompensated tinnitus, negative emotions are associated with the perception of sound because of impaired processing of a global network workspace. This can lead to assignment of negative appraisals of events and distorted misinterpretation to tinnitus perception, leading to anxiety and depression (Georgiewa et al. 2006). Individuals with tinnitus often report poor mental health and score lower on self-esteem and overall well-being than individuals without tinnitus (Krog et al. 2010). As THI scores have been correlated with anxiety, depression, and quality of life (Zeman et al. 2014; Hu et al. 2015), it is likely that participants with a high THI score in the present study experience anxiety, depression, and poor quality of life.

The current literature shows that students in higher education experience high levels of overall psychological distress compared to the general population (Humphris et al. 2002; Dyrbye et al. 2006; Nerdrum et al. 2006; Verger et al. 2009; Stallman 2010; Vazquez et al. 2012). Psychological distress has been widely used as an indicator of mental health (Drapeau et al. 2012). Some researchers consider it as a transient emotional response to stress-causing factors (such as tinnitus), while others consider it a relatively stable mental condition (Horwitz 2007; Deasy et al. 2014). The general consensus is that psychological distress is a mental state characterized by anxiety and depression, which may have a deleterious effect upon mental health and well-being if left untreated (Deasy et al. 2014). The present study reiterated that tinnitus likely contributes to the overall psychological distress experienced by college-aged individuals. This finding has been demonstrated in other studies and patient groups (Zeman et al. 2014; Hu et al. 2015). Similarly, untreated tinnitus may induce deleterious effects on mental health of college-aged individuals.

Limitations of the Study

This study was limited by its survey design. Although it estimated audiological factors such as routine acoustic exposure and hearing loss using validated survey tools, audiological factors can be measured more precisely by laboratory techniques such as audiometry to assess hearing loss and noise dosimetry to quantify acoustic exposure. In addition, this study assessed SLT using a set of questions used by previous researchers (Tyler et al. 2003; Gu et al. 2010; Knudson et al. 2014). This measure is not adequately comprehensive to quantify hyperacusis and neglects the important psychological effect of disordered sound tolerance. Therefore, the relation observed between SLT and tinnitus in the present study should be considered with caution. The study did not investigate use of recreational drugs, organic solvents, and other factors that might cause tinnitus in young adults (Rawool & Dluhy 2011; Rawool 2012a, b, 2016a, b). Furthermore, this study cannot rule out participation bias which may influence the sampling process by internally motivating potential participants with tinnitus and perceived tinnitus-related handicap to respond to the questionnaire. Fatigue and boredom may reduce the reliability of answers to questions completed at the end of the survey because of a relatively high number of total questions.

CONCLUSIONS

In conclusion, almost 8% of college-aged individuals experienced chronic tinnitus and almost 9% of individuals with any form of tinnitus reported more than a slight degree of perceived tinnitus-related handicap in daily living. Temporal characteristics of tinnitus, tinnitus loudness, and SLT were important predictors for tinnitus-related handicap. Future research is needed to explore genetic factors related to chronic tinnitus. Research efforts are also needed to explore the effects of chronic tinnitus and tinnitus-related handicap on audiological measures, educational achievements, social interaction, and vocational aspects of life for tinnitus sufferers.

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