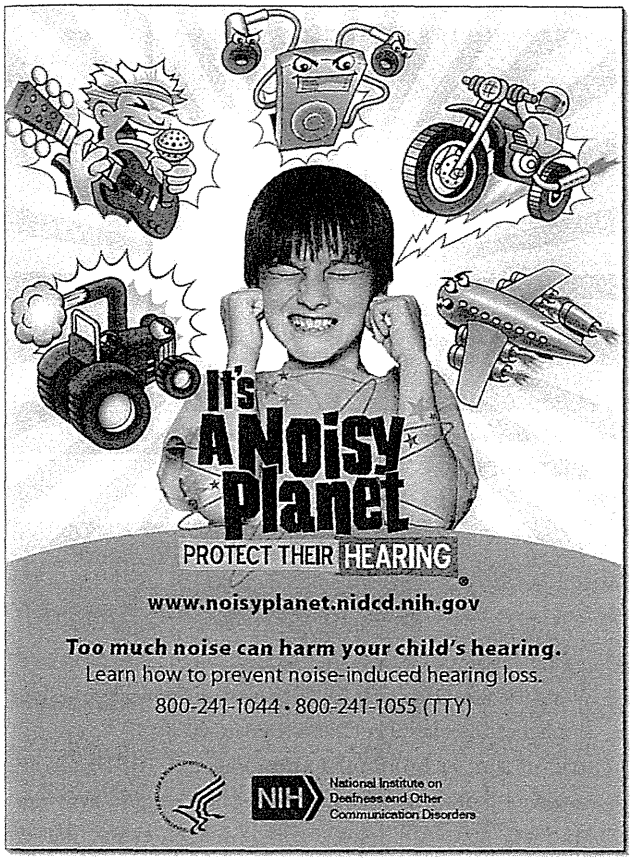

図2．NIH内の国立聴覚・コミュニケーション障害研究所(NIDCD)の，騒音性難聴予防の重要性を啓発する"Noisy Planet"キャンペーン

（文献3より引用改変）

パートであっても，言い換えれば「耳を鍛えている」プロであっても，音響曝露による物理的な身体への負担は軽減されないと認識すべきである。

音響による聴力障害には，突然の短時間の大音響曝露により生じる急性障害，急性音響外傷と，長年にわたる騒音の曝露によって生じる慢性の障害，騒音性難聴に大別される。職業性の場合も音楽由来であっても，急性，慢性，両方の音響による聴力障害の可能性がある。音響曝露後の聴力変化には，一過性聴力閾値上昇と永久性聴力閾値上昇がある（注：聴力閾値上昇は，聴力低下を意味する）。一過性聴力閾値上昇は大音響に曝露された後に聴力低下を示すが，時間が経つと曝露前のレベルに回復する可逆的変化で，聴覚の疲労現象とも考えられている。しかし，繰り返し音響曝露があると負荷は蓄積し，完全に回復していない状態で次の音響曝露が加わることにより，回復しない永久性聴力閾値上昇となる。したがって，急性障害を起こすほどでない音響レベルであっても，休憩することなく，連日にわたり長時間の曝露が続くと，難聴は発生するのである。

空気の振動として耳に入る音の情報は，内耳の蝸牛に存在する有毛細胞によって，電気信号に変換されて脳へ伝えられている。有毛細胞が傷害されても再生する鳥類，魚類と違って，哺乳類では有毛細胞は自発的に再生することはなく，一度傷害されると恒久的なダメージとなる（図3）[5]。加齢による難聴でも有毛細胞の減少はみられるが，日常の音響曝露の蓄積が蝸牛の経年変化を加速する一要因であることは，多くの研究者が指摘している。

耳を鍛えるのでなく，耳を通して脳を鍛える

音楽を大音量で聴くことが，難聴のリスクになることを前半で述べたが，一方で音楽的トレーニングや経験が，脳の構造や働きを変化させ，音声言語処理機能によい影響をもたらすことが知られている。なぜ音楽的トレーニングがことばの処理に関するネットワークに影響するのかは，神経生物学的な仮説により説明されている。KrausとChandrasekaranは，音楽もことばも，音のピッチ（高低），タイミング，音色により情報を伝えるという共通性から，ミュージシャンでは，異なる楽器の音色を正確に聴き分けるように，音声の原音に忠実な神経反応を示したり，入力音に対する神経応答速度が鋭敏であるなど，ミュージシャン以外の者に比べて優れた働きが確認されていることを報告している[6]。

高齢になると一般に言語理解能力が落ちてくるが，BidelmanとAlainは，若い頃に音楽トレーニングを受けている人は，高齢期の言語理解能力低下が軽いと論文発表した[7]。14歳より前から音楽トレーニングを始めている平均年齢70.1歳のアマチュア楽器演奏家10名と，平均69.6歳の音楽トレーニングを行っていない10名を対象に，ことばを聴き取るときの脳の働きを脳波で詳細に調べた。アマチュア楽器演奏家では，母音識別を行うとき，より迅速でより強い神経活動が観察された。このような

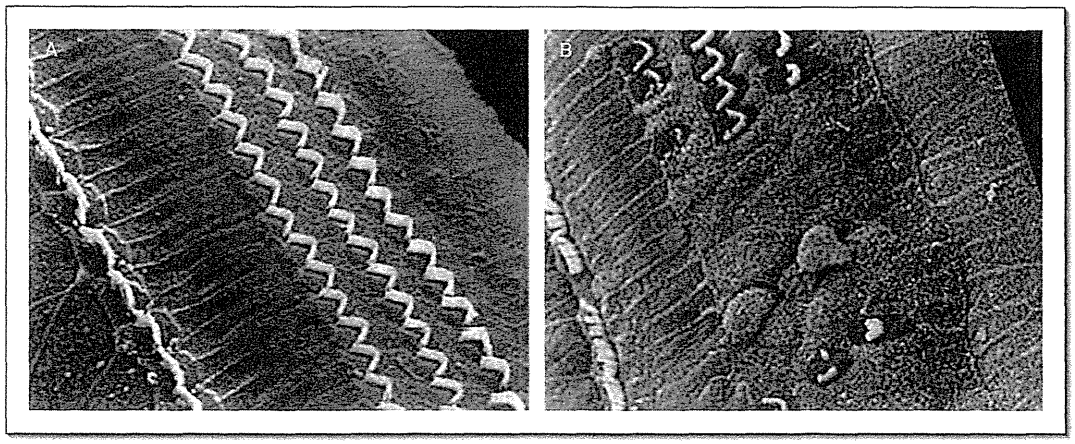

図3．電子顕微鏡による哺乳類内耳有毛細胞の観察：健康な蝸牛と傷ついた蝸牛
A：哺乳類の健康な蝸牛。有毛細胞が整然と並んでいる。
B：音響によってダメージを受けた蝸牛。破壊された有毛細胞は二度と再生しない。
（文献5より引用改変）

トレーニングによる神経機能の可塑性（神経可塑性：神経系が外界の刺激などの入力に反応し，機能的，構造的な変化を起こす性質）が，若年者に限ってみられる現象ではなく，高齢期においても維持されていたと証明されたことは意義深い。

実は，音楽の演奏を聴いて音程を正確に識別したり，一度聴いた旋律を記憶する音楽的能力が脳科学的に説明されるようになったのは，1600年代のトマス・ウィリスらに遡るとされる[8]。音を聴くことにより鍛えることができるのは，耳ではなく脳の聴覚的能力なのである。

おわりに

耳は鍛えて頑強にすることはできない。大きすぎるレベルの音を聴いたり，長時間聴きすぎると疲労現象を起こしたり，回復不能に陥るという繊細な構造をもつ。長寿命を実現した我々日本人は，このデリケートな耳の健康を長く維持するために，日頃から耳を労り，大切に守る努力が必要であろう。

●文　献

1）World Health Organization：(Nonserial Publication) Global Burden of Disease (The). 2004, Update 2008
2）Prevention of blindness and deafness (PBD)：Make Listening Safe. http://www.who.int/pbd/deafness/activities/MLS/en/, http://www.who.int/pbd/deafness/activities/IECD_2015_Press_Release_EN.pdf (Accessed March 2015)
3）It's a Noisy Planet. Protect Their Hearing® http://www.noisyplanet.nidcd.nih.gov/Pages/Default.aspx (Accessed March 2015)
4）Schink T, Kreutz G, Busch V, et al：Incidence and relative risk of hearing disorders in professional musicians. Occup Environ Med 71：472-476, 2014
5）Groves A：Can we regenerate the inner ear by teaching old cells new tricks? Tinnitus Today 33：11, 16-17, 2008
6）Kraus N, Chandrasekaran B：Music training for the development of auditory skills. Nat Rev Neurosci 11：599-605, 2010
7）Bidelman GM, Alain C：Musical training orchestrates coordinated neuroplasticity in auditory brainstem and cortex to counteract age-related declines in categorical vowel perception. J Neurosci 35：1240-1249, 2015
8）大愛崇晴：トマス・ウィリスの「音楽的な耳」と音楽の快の知覚：科学革命期の英国における神経生理学と聴覚的感性. 美學 63：133-144, 2012

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Gender difference in the relationships between vision and hearing impairments and negative well-being

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ABSTRACT

Objectives. To evaluate the association of hearing impairment, vision impairment and their combination (dual sensory impairment) with negative well-being such as depression, subjective poor health and the reduced functional ability in community-dwelling older adults, and to determine whether any association varies by gender.

Methods. Between 2005 and 2006, we objectively examined vision and hearing impairment (using best-corrected visual acuity and pure-tone audiometric test) in 843 people aged 65 years and older (351 males, 492 females) in a rural Japanese town. Through a home visit interview survey using a structured questionnaire, we also collected information on depression (the five-item Geriatric Depression Scale), subjective poor health, and reduced functional activity (the Tokyo Metropolitan Institute of Gerontology's Index of Competence).

Results. We observed gender differences in the association between sensory impairment and depression. Multiple logistic regression analysis revealed that hearing impairment in males (adjusted odds ratio: 2.22, 95% confidence interval; 1.07–4.61) and vision impairment in females (1.91, 1.14–3.21) were related to depression. Vision impairment and dual sensory impairment were also associated with subjective poor health and reduced functional activity in both sexes.

Conclusions. Sensory impairment is significantly associated with negative well-being in older persons, and its association with depression may differ between males and females.

Introduction

Vision and hearing impairments are common in aged populations. In the United States, 15% of individuals between 65 and 79 years old report vision impairment, and 35% report hearing impairment; for those aged 80 and older, the corresponding figures are 25% and 53% (Caban et al., 2005). In Japan, no nation-wide epidemiological survey of sensory impairment has ever been carried out, but the nation's long life expectancy suggests that substantial numbers of elderly Japanese have seeing or hearing difficulties (Uchida et al., 2003).

Recent evidence that vision and hearing impairments are related to negative well-being, including depression, disability, reduced self-sufficiency, and diminished physical function, highlights the importance of studying age-related declines in sensory functions among elderly people (Carabellese et al., 1993; Wallhagen et al., 2001; Heine and Browning, 2002; Lupsakko et al., 2002; Chou and Chi, 2004; Brennan et al., 2005; Capella-McDonnall, 2005; Chia et al., 2006; Ostbye et al., 2006). Further research on the relationships between vision and hearing impairments and negative well-being is necessary because, whereas the effect of vision loss only or hearing loss only on negative well-being has been investigated, the combined effects of vision and hearing loss have yet to be determined conclusively (Lupsakko et al., 2002; Chou and Chi, 2004; Chia et al., 2006). Also, studies using objective examinations of vision/hearing impairments instead of subjects' self-reporting are very limited (Carabellese et al., 1993; Chia et al., 2006).

In this study, we hypothesized that gender differences may exist in the associations between sensory impairments and negative well-being; such differences would indicate that gender-specific health policies are necessary to maintain quality of life for older persons. This is a reasonable hypothesis given the accumulating evidence of gender differences in the factors contributing to older adults' well-being (Osada et al., 1995; Yan et al., 2004; Katsura et al., 2007; Taş et al., 2007) as well as in the prevalence of sensory impairments (Campbell et al., 1999).

We examined vision/hearing impairments by objective methods and evaluated the association between negative well-being and hearing impairment only, vision impairment only, and their combination (dual sensory impairment) in community-dwelling older adults, with the aim of determining whether any association varies by gender.

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Methods

Study population

The target population was the older residents of Kurabuchi Town (Takasaki City, Gunma Prefecture), a rural mountain village with a population of approximately 4800. We defined eligible population as all residents in this town excluding those hospitalized or institutionalized persons and identified 1446 eligible subjects aged 65 years or older. A home visit interview survey was carried out by trained public health nurses and local welfare commissioners using a structured questionnaire to collect subjective health data between 2005 and 2006. During the same period, objective data was collected through free medical assessments of sensory functions at eight town community centers. The home visit survey and medical assessments were conducted with the cooperation of the local government. Of the 1446 eligible persons, 1372 (95%) answered the survey. Of these 1372 residents, 843 (351 males and 492 females, accounting for 58% of the eligible residents) submitted to the medical assessments; these 843 were subject to later analysis.

Compared to the survey-only participants, the survey/assessment participants included a higher proportion of females and were younger and more educated (Table 1). However, there were no significant differences between the two groups in terms of difficulty reading a newspaper or hearing, indicating that the survey/assessment participants adequately represented the whole study population.

The study was approved by the Medical Ethics Committee of the School of Medicine, Keio University, Tokyo, Japan, and all the subjects gave written informed consent without any incentives.

Vision and hearing impairments

At the medical assessments, trained technicians measured corrected visual acuity in each eye with a Landolt broken ring chart at 5 m using an automatic visual analyzer (TOMEY NS-1100, Nagoya, Japan). We defined visual impairment as a corrected visual acuity of worse than 0.5 in the better eye according to the United States criteria for visual impairment (Munoz et al., 2000). The subjects were also asked whether they had ever been diagnosed with cataracts.

Trained technicians conducted pure-tone air-conduction audiometry tests (RION AA-56, Tokyo, Japan) of both ears in a separate quiet room. Because of the field setting, only two signals were tested: 30 dB at 1 kHz and 40 dB at 4 kHz, the two measurements designated by the Japanese Industrial Safety and Health Law for workers' health examinations. In the current study, subjects were classified as belonging to the hearing impairment group if they failed to hear the 30-dB signal at 1 kHz bilaterally, because daily conversation relies more on low-frequency than on high-frequency hearing function. Indeed, people with hearing impairment at 1 kHz have been shown to be more sensitive to their perceived hearing difficulty than those with hearing impairment at 4 kHz (Okamoto et al., 2004). Information on hearing aid usage was collected, and the audiometric examinations were conducted without subjects wearing hearing aids.

Subjects who had both vision and hearing impairment were defined as having dual sensory impairment. All subjects were categorized into one of four groups: dual sensory impairment (DSI); vision impairment only (VIO); hearing impairment only (HIO); or no sensory impairment (NSI).

Outcome measurements

We evaluated three negative well-being measures through the survey and the medical assessments: depression; self-perceived poor health; and reduced functional activity. Depression is the most prevalent mental health problem and significantly reduces quality of life in the elderly (Blazer, 2003). Self-perceived poor health and reduced functional activity are also very good predictors of frailty and deterioration of well-being (Neale et al., 2001).

Depressive symptoms were evaluated with a five-item version of the Geriatric Depression Scale (GDS5). Using clinical evaluation as the gold standard for depression, GDS5 is as valid and effective as the 15-item GDS (Hoyl et al., 1999; Comprehensive Geriatric Assessment Guideline Study Group, 2003). GDS5 also has good interrater reliability (κ=0.88) and test–retest reliability (κ=0.84) (Rinaldi et al., 2003). Each item consists of a yes/no question, the total score ranging between 0 (best) and 5 (worst). We classified subjects scoring two or higher in the GDS5 as being depressed (Hoyl et al., 1999).

Participants who ranked their health status as "poor" or "very poor" (rather than "very good", "good", or "fair") were considered to be in poor health.

Functional activity was evaluated according to the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC) (Koyano et al., 1991). This 13-item index has a good test–retest reliability and assesses instrumental self-maintenance (the ability to use public transport, buy daily necessities, prepare meals, pay bills, handle banking matters), intellectual activity (filling out forms, reading daily newspapers, reading books/magazines, having interest in television programs or health-related news articles), and social role (ability to visit friends, give advice to relatives/friends, visit someone in the hospital, initiate a conversation with younger people). The unweighted sum of the questions (yes/no basis) is the total score, ranging from 0 (worst) to 13 (best). No universally accepted cutoff point has ever been proposed. In this study, subjects scoring 10 or lower (the lowest decile) were defined as having reduced functional activity. Changing the cutoff score to 9 or 11 did not substantially alter the relationships between sensory impairments and functional activity.

Covariates

Demographic and socio-economic information, including age, education (high school or higher/junior high or lower), past/current medical history of life-threatening diseases (including cancer, stroke, myocardial infarction, angina and diabetes mellitus), living situation (living alone or with spouse/family/others), current smoking and

Table 1
Characteristics of survey/assessment participants and survey-only participants (1372 older adults in Japan 2005–2006)

		Survey/assessment participants (n=843)	Survey only participants (n=529)	p value[b]
		n (column %)[a]	n (column %)[a]	
Sex				
	Male	351 (41.6)	253 (48.1)	0.02
	Female	492 (58.4)	273 (51.9)	
Age				
	65–69	199 (23.6)	114 (21.7)	<0.01
	70–79	429 (50.9)	221 (42.0)	
	80	215 (25.5)	191 (36.3)	
Education				
	High school or higher	187 (23.4)	93 (18.1)	0.05
	Elementary or junior high	613 (76.6)	421 (81.9)	
Difficulty seeing				
	Yes	69 (8.8)	61 (12.0)	0.34
	No	720 (91.2)	449 (88.0)	
Difficulty hearing				
	Yes	96 (12.3)	93 (17.9)	0.18
	No	686 (87.7)	425 (82.1)	

[a] Because of missing values, numbers of subjects do not always add up to 843 and 529, respectively.
[b] For age and sex, p value of χ^2 test is shown; for the rest, p value of Mantel–Haenszel χ^2 test adjusting age and sex is shown.

Table 2
Prevalence of single and dual sensory impairments by age and gender (843 older adults in Japan 2005–2006)

Age category	No sensory impairment	Vision impairment only	Hearing impairment only	Dual sensory impairment
	Number (%)	Number (%)	Number (%)	Number (%)
Male				
Total	234 (66.7)[a]	46 (13.1)[a]	49 (14.0)	22 (6.3)[a]
65–69	76 (88.4)[b]	7 (8.1)	3 (3.5)[b]	0[b]
70–79	120 (65.9)	28 (15.4)	26 (14.3)	8 (4.4)
80–	38 (45.8)	11 (13.3)	20 (24.1)	14 (16.9)
Female				
Total	249 (50.6)	115 (23.4)	68 (13.8)	60 (12.2)
65–69	88 (77.9)[b]	15 (13.3)[b]	4 (3.5)[b]	6 (5.3)[b]
70–79	125 (50.6)	64 (25.9)	37 (15.0)	21 (8.5)
80–	36 (27.3)	36 (27.3)	27 (20.5)	33 (25.0)
Combined				
Total	483 (57.3)	161 (19.1)	117 (13.9)	82 (9.7)
65–69	164 (82.4)[b]	22 (11.1)[b]	7 (3.5)[b]	6 (3.0)[b]
70–79	245 (57.1)	92 (21.5)	63 (14.7)	29 (6.8)
80–	74 (34.4)	47 (21.9)	47 (21.9)	47 (21.9)

[a] $p<0.05$ for comparison between sex by χ^2 test (for total).
[b] $p<0.05$ by score test for trend.

alcohol drinking, was also collected through the survey. In line with earlier studies, these factors were selected as a priori confounders for this study (Wallhagen et al., 2001; Brennan et al., 2005; Capella-McDonnall, 2005; Chou, 2008).

We held two one-hour training sessions for the examiners and interviewers, instructing them to follow the standardized manual.

Statistical analysis

STATA 9.1 (Stata Corporation, College Station, Texas) was used for all analyses.

The prevalence of NSI, VIO, HIO and DSI according to age and gender was calculated. The association of single and dual sensory impairment with depression, self-perceived poor health, and reduced functional activity was assessed first by crude analyses. Then, by using unconditional multiple logistic models, the a priori confounders (age (continuous), education, past/current medical history of life-threatening diseases, living situation, current smoking and alcohol drinking) were adjusted for. There were no interactions either among these covariates or between the sensory impairment variables and covariates. The odds ratio (OR) and its 95% confidence interval (CI) were used to present the strength of the association with respect to NSI.

Since one of the aims of this study was to investigate gender differences in the relationships between sensory impairments and negative well-being outcomes, all analyses were performed after stratification by sex. A statistical check for interaction by sex was also carried out using the likelihood ratio test for interaction.

The χ^2 test or Fisher's exact method was used to compare the prevalence of each impairment group as needed. Trends according to age category were checked with a score test (Altman, 1991).

Results

Table 2 presents the prevalence of single and dual sensory impairment by age in males, females, and combined subjects. A higher proportion of females (23%) than males (13%) had VIO, while

Table 3
Characteristics of the subjects with single and dual sensory impairment (843 older adults in Japan 2005–2006)

Variable	No sensory impairment	Vision impairment only	Hearing impairment only	Dual sensory impairment	p value[b]
	Number (column%)[a]	Number (column%)[a]	Number (column%)[a]	Number (column%)[a]	
Male	(n=234)	(n=46)	(n=49)	(n=22)	
Education					
High school or higher	64 (28.8)	6 (14.3)	14 (29.8)	2 (10.0)	0.07
Junior high or lower	158 (71.2)	36 (85.7)	33 (70.2)	18 (90.0)	
Current/past histories of life-threatening diseases					
Yes	68 (30.9)	12 (29.3)	13 (28.3)	10 (47.6)	0.41
No	152 (69.1)	29 (70.7)	33 (71.7)	11 (52.4)	
Living alone					
Yes	16 (7.2)	6 (14.3)	5 (10.4)	1 (4.8)	0.41
No	205 (92.8)	36 (85.7)	143 (89.6)	20 (95.2)	
Current smoker					
Yes	57 (25.6)	14 (33.3)	13 (27.1)	5 (23.8)	0.76
No	166 (74.4)	28 (66.7)	35 (72.9)	16 (76.2)	
Current alcohol drinker					
Yes	128 (57.9)	26 (61.9)	23 (47.9)	13 (61.9)	0.51
No	93 (42.1)	16 (38.1)	25 (52.1)	8 (38.1)	
Female	(n=249)	(n=115)	(n=68)	(n=60)	
Education					
High school or higher	65 (27.8)	14 (12.7)	12 (18.5)	10 (16.7)	<0.01
Junior high or lower	169 (72.2)	96 (87.3)	53 (81.5)	50 (83.3)	
Current/past histories of life-threatening diseases					
Yes	31 (13.4)	30 (27.0)	17 (27.4)	17 (28.8)	<0.01
No	200 (86.6)	81 (73.0)	45 (72.6)	42 (71.2)	
Living alone					
Yes	31 (13.4)	16 (14.4)	12 (18.8)	14 (23.3)	0.25
No	200 (86.6)	95 (85.6)	52 (81.3)	46 (76.7)	
Current smoker					
Yes	8 (3.4)	3 (2.7)	2 (3.1)	2 (3.3)	1.00
No	227 (96.6)	109 (97.3)	63 (96.9)	58 (96.7)	
Current alcohol drinker					
Yes	39 (16.7)	9 (8.0)	7 (10.9)	5 (8.5) 0.1	
No	194 (83.3)	103 (92.0)	57 (89.1)	54 (91.5)	

[a] Due to missing values, the denominator of column percentage for each variable does not exactly match the total subject number of each subgroup.
[b] p value for χ^2 test or Fisher's exact method.

there was no statistically significant gender difference in the HIO prevalence. Females were twice as likely to suffer from DSI as males (12% vs. 6%). The prevalence of single and dual sensory impairment increased with age, except for VIO in males.

Table 3 shows the characteristics of the NSI, VIO, HIO and DSI subjects. The subjects with DSI tended to be less educated. The women with NSI were less likely to have a past or current history of life-threatening diseases. Among the four groups, the prevalence of current alcohol drinkers among the females varied, whereas neither the living situation nor the proportion of current smokers varied in either sex.

Table 4 summarizes the crude and adjusted associations of sensory impairments with depression, self-perceived poor health, and reduced functional activity. We observed depression-related gender differences. The likelihood ratio test for interaction by sex showed moderate evidence of interaction ($p=0.15$). In males, hearing impairment was related to elevated odds of depression, even after adjusting for covariates (adjusted OR and 95% CI: 2.20, 1.06–4.58), but vision impairment was not. In contrast, female subjects with vision impairment were twice as likely to suffer from depression (adjusted OR and 95% CI: 2.00, 1.19–3.35), while hearing impairment did not affect the odds of depression. Having both vision and hearing impairments was associated with a three times greater chance of depression in both sexes.

Vision impairment showed an association with increased odds of self-perceived poor health in both sexes. Although the relationship was weaker in females (adjusted OR and 95% CI: 1.72, 0.63–4.74) than in males (3.92, 1.36–11.25), there was no statistical interaction by sex ($p=0.73$). No relationship was seen between hearing impairment and self-perceived poor health. DSI subjects were more than three times as likely to perceive themselves as being in poor health.

As with self-perceived poor health, vision impairment was related to reduced functional activity in both sexes, but hearing impairment was not. No statistical interaction by sex was observed ($p=0.92$). DSI also had a statistically significant association with reduced functional activity.

Of the subjects with hearing impairment, 36 reported that they used hearing aids. Including hearing aid usage as an explanatory variable in the models did not change the results substantially.

Table 4
The association of sensory impairment with depression, self-perceived poor health and reduced functional activity (843 older adults in Japan 2005–2006)

	Number (%)	Crude odds ratio (95% CI)	Adjusted odds ratio[a] (95% CI)
Male			
Depression			
NSI[b]	47/231 (20.4)	1.00	1.00
VIO[c]	10/46 (21.7)	1.09 (0.50–2.35)	1.06 (0.48–2.38)
HIO[d]	17/48 (35.4)	2.15 (1.09–4.24)	2.20 (1.06–4.58)
DSI[e]	11/22 (50.0)	3.92 (1.57–9.78)	2.80 (0.99–7.89)
Self-perceived poor health			
NSI[b]	13/222 (5.9)	1.00	1.00
VIO[c]	7/42 (16.7)	3.21 (1.18–8.73)	3.92 (1.36–11.25)
HIO[d]	2/48 (4.2)	0.70 (0.15–3.22)	0.95 (0.19–4.63)
DSI[e]	3/21 (14.3)	2.68 (0.69–10.37)	3.46 (0.72–16.67)
Reduced functional activity			
NSI[b]	16/222 (7.2)	1.00	1.00
VIO[c]	12/42 (28.6)	5.15 (2.16–12.30)	4.94 (2.07–11.78)
HIO[d]	6/48 (12.5)	1.84 (0.68–5.00)	1.74 (0.61–4.95)
DSI[e]	6/20 (30.0)	5.51 (1.81–16.78)	5.99 (1.75–20.53)
Female			
Depression			
NSI[b]	59/244 (24.2)	1.00	1.00
VIO[c]	51/115 (44.4)	2.50 (1.54–4.04)	2.00 (1.19–3.35)
HIO[d]	21/67 (31.3)	1.43 (0.79–2.60)	1.28 (0.66–2.48)
DSI[e]	33/60 (55.0)	3.83 (2.08–7.05)	3.04 (1.63–6.07)
Self-perceived poor health			
NSI[b]	9/234 (3.9)	1.00	1.00
VIO[c]	9/112 (8.0)	2.18 (0.84–5.69)	1.72 (0.63–4.74)
HIO[d]	2/65 (3.1)	0.79 (0.17–3.78)	0.73 (0.14–3.72)
DSI[e]	8/60 (13.3)	3.84 (1.39–10.61)	3.72 (1.19–11.66)
Reduced functional activity			
NSI[b]	13/229 (5.7)	1.00	1.00
VIO[c]	27/111 (24.3)	5.34 (2.56–11.16)	3.56 (1.67–7.61)
HIO[d]	8/65 (12.3)	2.33 (0.92–5.94)	1.21 (0.45–3.28)
DSI[e]	20/60 (33.3)	8.31 (3.62–19.06)	3.45 (1.44–8.27)

[a] Adjusted for age, education, past/current history of life-threatening diseases, living situation, smoking and alcohol drinking.
[b] NSI, no sensory impairment.
[c] VIO, vision impairment only.
[d] HIO, hearing impairment only.
[e] DSI, dual sensory impairment.

Discussion

In this community-based study of Japanese older adults, we found a clear association between single/dual sensory impairments and three negative well-being measures: depression; self-perceived poor health; and reduced functional activity. We stratified our data by sex according to our hypothesis that gender difference may exist in the associations between sensory impairments and negative well-being.

Gender differences were clearly seen in the association between sensory impairment and depression: whereas men with hearing impairment were more likely to be depressive than men without, vision impairment seemed to be a stronger factor in depression among women. Although the likelihood ratio test for interaction showed only moderate evidence for this, the statistical power to detect interactions is generally known to be weak (Silva, 1999). Moreover, there is accumulating evidence of gender differences both in the factors influencing depression (Weissman and Klerman, 1977; Kuehner, 2003; Tsuboi et al., 2004) and in the prevalence of sensory impairments (Campbell et al., 1999). To the best of our knowledge, this is the first study describing gender difference in the relationships between vision and hearing impairments and depression, and its underlying mechanism is unclear. One tentative explanation may be found in the relatively distinct gender-specific social roles and characteristics in this generation. Japanese women of this generation usually do all of the housework, while men after retirement tend to be withdrawn from social activities (Takahashi et al., 2003). Therefore, visual impairment may cause more difficulties and deprivation in the daily lives of women, leading to depression. Meanwhile, communication problems and subsequent social isolation caused by hearing impairment may play a greater role in bringing on depressive symptoms in males by depriving them of the already limited social interaction.

Other studies on the relationship between sensory impairment and depression have shown inconsistent results (Carabellese et al., 1993; Wallhagen et al., 2001; Chou and Chi, 2004; Capella-McDonnall, 2005; Ishine et al., 2007). Some have indicated that both vision and hearing impairment have an association with depression (Carabellese et al., 1993; Capella-McDonnall, 2005). Others have shown that vision impairment has a greater relationship with depression than hearing (Wallhagen et al., 2001; Chou and Chi, 2004). An earlier study in Japan reported a close association between hearing impairment and depression in community-dwelling older people, but vision impairment was not assessed (Ishine et al., 2007). The inconsistencies in these study results may be due to different evaluation methods for sensory impairment and for depression, and to different study population characteristics. Our study provides a new interpretation and suggests a need for further investigation of the association between sensory impairment and depression.

Self-perceived poor health, the second negative well-being measure, showed an association in both sexes with vision impairment but not with hearing impairment. In an earlier study, both visual and hearing acuity were shown to predict self-reported health

independently, but visual acuity was shown to be a more significant factor than hearing acuity (Ostbye et al., 2006). Our findings agree with this earlier study, but are even more pronounced. As self-perceived poor health is known to predict mortality, our results may also support another study showing that measured visual impairment but not measured hearing impairment was predictive of mortality (Reuben et al., 1999). Older adults may tend to perceive vision loss a more serious health condition than hearing loss.

Reduced functional activity, the third negative well-being measure, showed an association with vision impairment but not with hearing impairment. This may be partially due to the fact that the index of competence used in this study (TMIG-IC) includes three questions closely related to visual acuity (the ability to fill out forms, read daily newspapers, read books/magazines) and only one question directly related to hearing acuity (the ability to initiate a conversation with younger people). However, as a similar finding was reported in an earlier cohort study (Reuben et al., 1999), this association is unlikely to be solely due to the content of the questions.

Despite the strengths of the present study (the use of objective sensory measurements, three different well-being outcomes, and stratified analysis according to gender), there are also limitations. First, due to the field setting nature of the study, only the essential and minimal measurement items were used for classifying sensory impairments: hearing impairment was assessed by a single frequency, and visual impairment was evaluated by distance visual acuity. Therefore, misclassification of sensory impairments may have occurred, but such misclassification would likely occur non-differentially and lead to bias towards the null. Second, since our analytic model focused on life-threatening diseases, potential confounding by other chronic conditions cannot be entirely ruled out. Third, the cross-sectional design prevented us from making causal inferences from the observed associations. Finally, since we used a 5-item depression scale rather than a psychiatrist's diagnosis, the observed associations cannot be applied to clinical depression.

DSI subjects accounted for a substantial proportion of the study population. The significant association between DSI and negative well-being strongly implies that DSI sufferers should be given priority in the provision of healthcare, including both medical treatment and rehabilitation programs. For example, more urgent treatment for cataracts and diabetic retinopathy along with the provision of hearing aids might be considered. The gender differences related to depression observed in this study also suggest a need for gender-specific strategies in healthcare policies.

Conclusions

The present study results suggest that sensory impairment is prevalent among community-dwelling older adults, and that sensory impairment has a significant association with depression, subjective poor health, and declines in functional ability. A clear gender difference was observed in the association between sensory impairment and depression: vision impairment appears to play a significant role in depression among females, while hearing impairment may play a more significant role among males. With the aging of Japanese society, the screening, prevention and treatment of sensory impairment in community-dwelling older adults is likely to become an important issue in preventing a decline in quality of life for older adults.

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References

Altman, D., 1991. Practical Statistics for Medical Research. Chapman & Hall, London.
Blazer, D.G., 2003. Depression in late life: review and commentary. J. Gerontol. A Biol. Sci. Med. Sci. 58, 249–265.
Brennan, M., Horowitz, A., Su, Y.P., 2005. Dual sensory loss and its impact on everyday competence. Gerontologist 45, 337–346.
Caban, A.J., Lee, D.J., Gomez-Marin, O., et al., 2005. Prevalence of concurrent hearing and visual impairment in US adults: the National Health Interview Survey, 1997–2002. Am. J. Public Health 95, 1940–1942.
Campbell, V.A., Crews, J.E., Moriarty, D.G., et al., 1999. Surveillance for sensory impairment, activity limitation, and health-related quality of life among older adults—United States, 1993–1997. MMWR CDC Surveill. Summ. 48, 131–156.
Capella-McDonnall, M.E., 2005. The effects of single and dual sensory loss on symptoms of depression in the elderly. Int. J. Geriatr. Psychiatry 20, 855–861.
Carabellese, C., Appollonio, I., Rozzini, R., et al., 1993. Sensory impairment and quality of life in a community elderly population. J. Am. Geriatr. Soc. 41, 401–407.
Chia, E.M., Mitchell, P., Rochtchina, E., et al., 2006. Association between vision and hearing impairments and their combined effects on quality of life. Arch. Ophthalmol. 124, 1465–1470.
Chou, K.L., 2008. Combined effect of vision and hearing impairment on depression in older adults: evidence from the English Longitudinal Study of Ageing. J. Affect. Disord. 106, 191–196.
Chou, K.L., Chi, I., 2004. Combined effect of vision and hearing impairment on depression in elderly Chinese. Int. J. Geriatr. Psychiatry 19, 825–832.
Comprehensive Geriatric Assessment Guideline Study Group, 2003. Comprehensive Geriatric Assessment. Kousei-kagaku-kenkyujo, Tokyo.
Heine, C., Browning, C.J., 2002. Communication and psychosocial consequences of sensory loss in older adults: overview and rehabilitation directions. Disabil. Rehabil. 24, 763–773.
Hoyl, M.T., Alessi, C.A., Harker, J.O., et al., 1999. Development and testing of a five-item version of the Geriatric Depression Scale. J. Am. Geriatr. Soc. 47, 873–878.
Ishine, M., Okumiya, K., Matsubayashi, K., 2007. A close association between hearing impairment and activities of daily living, depression, and quality of life in community-dwelling older people in Japan. J. Am. Geriatr. Soc. 55, 316–317.
Katsura, H., Yamada, K., Wakabayashi, R., et al., 2007. Gender-associated differences in dyspnoea and health-related quality of life in patients with chronic obstructive pulmonary disease. Respirology 12, 427–432.
Koyano, W., Shibata, H., Nakazato, K., et al., 1991. Measurement of competence: reliability and validity of the TMIG Index of Competence. Arch. Gerontol. Geriatr. 13, 103–116.
Kuehner, C., 2003. Gender differences in unipolar depression: an update of epidemiological findings and possible explanations. Acta. Psychiatr. Scand. 108, 163–174.
Lupsakko, T., Mantyjarvi, M., Kautiainen, H., et al., 2002. Combined hearing and visual impairment and depression in a population aged 75 years and older. Int. J. Geriatr. Psychiatry 17, 808–813.
Munoz, B., West, S.K., Rubin, G.S., et al., 2000. Causes of blindness and visual impairment in a population of older Americans: the Salisbury Eye Evaluation Study. Arch. Ophthalmol. 118, 819–825.
Neale, R., Brayne, C., Johnson, A.L., 2001. Cognition and survival: an exploration in a large multicentre study of the population aged 65 years and over. Int. J. Epidemiol. 30, 1383–1388.
Okamoto, M., Nakanishi, N., Tatara, K., 2004. Self-reported hearing difficulty and hearing impairment in Japanese people living in a community. Int. J. Audiol. 43, 54–59.
Osada, H., Shibata, H., Haga, H., et al., 1995. Relationship of physical condition and functional capacity to depressive status in person aged 75 years. Nippon Koshu Eisei Zasshi 42, 897–909 in Japanese.
Ostbye, T., Krause, K.M., Norton, M.C., et al., 2006. Ten dimensions of health and their relationships with overall self-reported health and survival in a predominately religiously active elderly population: the cache county memory study. J. Am. Geriatr. Soc. 54, 199–209.
Reuben, D.B., Mui, S., Damesyn, M., et al., 1999. The prognostic value of sensory impairment in older persons. J. Am. Geriatr. Soc. 47, 930–935.
Rinaldi, P., Mecocci, P., Benedetti, C., et al., 2003. Validation of the five-item geriatric depression scale in elderly subjects in three different settings. J. Am. Geriatr. Soc. 51, 694–698.
Silva, I.d.S., 1999. Cancer Epidemiology: Principles and Methods. IARC Press, Lyon.
Takahashi, M., Shibazaki, S., Nagai, M., 2003. Characteristics of social activity of the elderly who belong to senior citizens. Nippon Koshu Eisei Zasshi 50, 970–979 in Japanese.
Taş, U., Verhagen, A.P., Bierma-Zeinstra, S.M., et al., 2007. Incidence and risk factors of disability in the elderly: the Rotterdam Study. Prev. Med. 44, 272–278.
Tsuboi, S., Fukukawa, Y., Niino, N., et al., 2004. Age and gender differences as factors related to depressive symptoms among community-dwelling middle-aged and elderly people. Shinrigaku Kenkyu 75, 101–108 in Japanese.
Uchida, Y., Nakashima, T., Ando, F., et al., 2003. Prevalence of self-perceived auditory problems and their relation to audiometric thresholds in a middle-aged to elderly population. Acta. Otolaryngol. 123, 618–626.
Wallhagen, M.I., Strawbridge, W.J., Shema, S.J., et al., 2001. Comparative impact of hearing and vision impairment on subsequent functioning. J. Am. Geriatr. Soc. 49, 1086–1092.
Weissman, M.M., Klerman, G.L., 1977. Sex differences and the epidemiology of depression. Arch. Gen. Psychiatry 34, 98–111.
Yan, L.L., Daviglus, M.L., Liu, K., et al., 2004. BMI and health-related quality of life in adults 65 years and older. Obes. Res. 12, 69–76.

BRIEF REPORTS

Hearing Handicap Predicts the Development of Depressive Symptoms After 3 Years in Older Community-Dwelling Japanese

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OBJECTIVES: To examine the association between hearing handicap and depressive symptoms in older community-dwelling Japanese.

DESIGN: Community-based cohort study.

SETTING: Kurabuchi Town, Gunma Prefecture, Japan.

PARTICIPANTS: Five hundred eighty residents (261 men, 319 women) aged 65 and older without depressive symptoms.

MEASUREMENTS: In a baseline examination performed in 2005/06, participants answered the 10-item screening version of the Hearing Handicap Inventory for Elderly (HHIE-S). They were divided into two groups according to their scores: a group with no hearing handicap (HHIE-S scores of ≤ 8) and a hearing handicap group (HHIE-S scores of ≥ 10). The Geriatric Depression Scale was used to identify depressive symptoms in face-to-face home visit interviews conducted in 2008, and the association between hearing handicap and depressive symptoms was assessed using logistic regression.

RESULTS: The incidence of depressive symptoms was 19.6% in the group with a hearing handicap and 8.0% in the group without a hearing handicap. When compared with the subjects without hearing handicap, subjects with a hearing handicap had a multiadjusted odds ratio of depressive symptoms of 2.45 (95% confidence interval = 1.26–4.77). The association remained significant even when hearing impairment measured with pure-tone audiometry was added to the multiadjusted model.

CONCLUSION: A hearing handicap can predict future depressive symptoms in older community-dwelling people. **J Am Geriatr Soc 58:93–97, 2010.**

Key words: hearing handicap; depression; aged; cohort studies

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In older populations, hearing impairment is common, with an estimated prevalence of between 30% and 60%,[1–5] and has a large effect on quality of life (QOL) in older adults.[6] Age-related hearing loss (ARHL) first reduces the ability to understand speech, especially in noisy conditions, and later, the ability to detect, identify, and localize sound.[6] Reduced ability to understand speech affects an individual's psychosocial situation and hence contributes to social isolation, depression, and loss of self-esteem, although studies vary in their assessments of associations between hearing impairment and mental health. Early studies indicated that hearing impairment has a strong association with depressive symptoms and dementia,[7,8] but more-recent studies have failed to show any relationship between higher audiometric thresholds and depression.[9,10]

ARHL is usually diagnosed on the basis of the results of several auditory tests such as pure-tone audiometry, and speech discrimination tests, but using these auditory tests presents problems in community-based settings, because strict background noise controls, expensive equipment, and trained technicians are required to perform them. Furthermore, these tests may fail to quantify the extent of the handicap caused by hearing impairment or identify the type of handicap (e.g., poor speech comprehension, disability in communication, social isolation, and failure to notice alarms).[11,12] Therefore, applying auditory tests alone to assess the association between hearing impairment and depression is probably not ideal, and it was decided to evaluate hearing handicap in addition to performing auditory examinations in this study. Of the several hearing handicap questionnaires available,[11,13,14] the 10-item screening version of the Hearing Handicap Inventory for Elderly (HHIE-S)[11] was chosen for the assessments. HHIE-S is well validated,[15] and it takes subjects only a few minutes to answer the questions, making it easy to apply to community-based research. Even so, few studies have evaluated the association between HHIE-S score and depression.[16]

The aim of this study was to determine whether hearing handicap as assessed using the HHIE-S can predict depressive symptoms, using data from a 3-year cohort study of older community-dwelling Japanese.

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METHODS

Study Population

The Kurabuchi study is an ongoing community-based cohort study of aging involving functional assessment of an older population in Kurabuchi Town, Takasaki City (approximately 100 km north of Tokyo, Japan).[17–19] In 2005/06, all residents aged 65 and older, excluding those hospitalized or institutionalized, were enrolled (n = 1,294); 825 (63.8%) participated in detailed health examinations, including hearing tests, performed in eight community centers. Those with depressive symptoms (Geriatric Depression Scale 5-item version (GDS5) score >1)[20] at baseline were further excluded, leaving 580 subjects (261 men, 319 women) for analysis.

The Ethics Committee of the School of Medicine, Keio University (Tokyo, Japan), approved the study protocol, and written informed consent was obtained from all participants.

Baseline Examinations

The Hearing Handicap Inventory for the Elderly (HHIE) was developed as a self-assessment tool for evaluating handicap from hearing loss in terms of the emotional and social state of elderly people.[12] The 10-item screening version of the HHIE,[15] HHIE-S, is also widely used and is well validated. Each item has three response options (no (score: 0), sometimes (score: 2), and yes (score: 4)), and the total score range is from 0 to 40. The subjects were divided into two groups according to their HHIE-S scores: a group with no hearing handicap (HHIE-S score <8) and a hearing handicap group (HHIE-S score ≥10).[21]

Information on educational level (junior high school vs high school or higher); living circumstances (alone vs with family); smoking status (current smoker vs not); alcohol drinking (current drinker vs not); hearing aid usage (yes vs no); and past or current history of major illness, including stroke, coronary heart disease, diabetes mellitus, cancer, and Parkinson's disease (summary of yes vs no). Because an earlier study had shown a relationship between vision impairment and depressive symptoms,[19] vision impairment (defined as a corrected distance visual acuity of worse than 0.5 in the better eye, measured using a Landolt broken ring chart at 5 m according to U.S. criteria[22]) was included as a potential confounding factor. Pure-tone air-conduction audiometry was performed in a separate quiet room with an audiometer (AA-56, RION Inc., Tokyo, Japan), which was calibrated regularly to comply with Japanese standards. Because of the field setting, only two signals were tested: 30 db at 1 kHz and 40 dB at 4 kHz, the two measurements designated by the Japanese Industrial Safety and Health Law for workers' health examinations. In the present study, subjects were classified as belonging to a measured hearing impairment group if they failed to hear a 30 dB hearing level signal at 1,000 Hz in the better ear[19] (daily conversation in Japanese relies more on low-frequency signals than high-frequency signals[23]).

Outcome

Trained public health nurses and local welfare commissioners conducted face-to-face home visit interviews in 2008, during which subjects' depressive symptoms were evaluated according to the Geriatric Depression Scale 15-item version (GDS15), one of the most useful and well-validated questionnaire for depression in older populations.[24] Each question in the scale elicits a yes-or-no response, and scores are the sum of the depressive symptoms reported. Subjects scoring 6 or more were defined as having depressive symptoms.[25]

Statistical Analysis

STATA version 9 (STATA Corp., College Station, TX) was used for all data analyses. The chi-square test and Fisher exact test were applied to compare the baseline characteristics of participants with and without a hearing handicap. To determine the relationship between hearing handicap and depressive symptoms, a logistic regression model was used, and odds ratios (ORs) of depressive symptoms were calculated. Age (continuous), sex, living circumstances, smoking status, alcohol drinking, past and current history of major illness, and measured vision impairment were included in the multiadjusted model (Model 1). To examine whether measured hearing impairment influenced the relationship between hearing handicap and depressive symptoms, hearing impairment based on pure-tone audiometry was added to Model 1 (Model 2). In this study, none of the variables included in the multiadjusted model were found to interact with hearing handicap in determining the association with depressive symptoms. A subgroup analysis excluding hearing aid users was also performed. Finally, all analyses were repeated assuming first that the subjects who were lost to follow-up had depressive symptoms and then that they did not.

RESULTS

Outcome information was obtained on 548 participants (94.5% of the original 580), with 32 lost to follow-up; 19 had died, eight had been admitted to a nursing home or hospital, two had moved out of town, and three refused to take part in home visit interviews. The followed participants were younger than those who were lost to follow-up, but there were no differences in sex distribution or percentage of hearing handicap between those followed and those lost.

The baseline characteristics of the subjects are shown in Table 1. There was a higher percentage of men in the hearing handicap group. The members of this group were also older and had higher percentages of past or current history of major illness, hearing impairment based on pure-tone audiometry, and hearing aid usage. In contrast, there were no differences between the two groups in educational level, smoking status, alcohol drinking, or measured vision impairment.

The relationship between hearing handicap and depressive symptoms is summarized inTable 2. Subjects with a hearing handicap (19.6%) had a higher incidence of depressive symptoms than those without (8.0% (P = .001). Using subjects without hearing handicap as the reference, the OR of depressive symptoms for subjects with hearing handicap was 2.45 (95% confidence interval [CI] = 1.26–4.77) after adjusting for age, sex, living circumstances, smoking status, alcohol drinking, past and current history

Table 1. Baseline Characteristics of Study Participants According to Hearing Handicap (2005/06)

Characteristic	n (%) No Hearing Handicap (n = 436)	n (%) Hearing Handicap (n = 112)*	P-Value†
Age			
65–69	122 (28.0)	12 (10.7)	
70–79	233 (53.4)	58 (51.8)	
≥80	81 (18.6)	42 (37.5)	<.001
Sex			
Female	250 (57.3)	48 (42.9)	
Male	186 (42.7)	64 (57.1)	.006
Education level			
Junior high school	298 (71.1)	83 (76.2)	
High school or higher	121 (28.9)	26 (23.8)	.30
Living alone			
Yes	47 (11.3)	8 (7.3)	
No	370 (88.7)	101 (92.7)	.23
Current smoker			
Yes	53 (12.6)	14 (12.8)	
No	369 (87.4)	95 (87.2)	.94
Current alcohol drinker			
Yes	136 (32.5)	38 (35.5)	
No	283 (67.5)	69 (64.5)	.55
Past or current history of major illness‡			
Yes	83 (20.0)	35 (33.3)	
No	333 (80.0)	70 (66.7)	.003
Measured vision impairment§			
Impaired	91 (20.9)	27 (24.1)	
Not impaired	344 (79.1)	85 (75.9)	.46
Measured hearing impairment‖			
Impaired	43 (9.9)	60 (54.0)	
Not impaired	393 (90.1)	51 (46.0)	<.001
Hearing aid usage			
Yes	2 (0.5)	22 (19.6)	
No	434 (99.5)	90 (80.4)	<.001

Number of cases may not add up to 436 or 112 because of missing data.
* Participants who had Hearing Handicap Inventory for the Elderly Screening scores of 10 or more were considered to have hearing handicap.
† Chi-square or Fisher exact test.
‡ Past or current history of major illness: stroke, coronary heart disease, diabetes mellitus, cancer, and Parkinson' disease.
§ Corrected distance visual acuity worse than 0.5 in the better eye.
‖ Failure to hear the 30 dB hearing level signal at 1 kHz in the better ear.

of major illness, and measured vision impairment (Model 1). Even when measured hearing impairment was added to the multiadjusted model (Model 2), hearing handicap remained an independent predictor of depressive symptoms (OR = 2.81, 95% CI = 1.30–6.07), although measured hearing impairment was not associated with depressive symptoms (OR of depressive symptoms = 0.77, 95% CI = 0.34–1.75). In a subgroup analysis excluding hearing aid users, hearing handicap was also associated with depressive symptoms (multiadjusted OR (Model 2) = 2.60, 95% CI = 1.17–5.77). In further analyses in which subjects who were lost to follow-up were first assumed to have depressive symptoms and then assumed not to, the results did not change substantially (multiadjusted OR (Model 2) = 2.59, 95% CI = 1.31–5.09, and multiadjusted OR (Model 2) = 2.69, 95% CI = 1.25–5.77, respectively).

Table 2. Depressive Symptoms for Hearing Handicap in Older Community-Dwelling Japanese

	No Hearing Handicap (n = 436)	Hearing Handicap (n = 112)*	P-Value
Depressive symptoms, n (%)†	35 (8.0)	22 (19.6)	
Crude, OR (95% CI)	Reference	2.80 (1.56–5.00)	.001
Age- and sex-adjusted, OR (95% CI)	Reference	2.25 (1.21–4.18)	.01
Model 1, OR (95% CI)‡	Reference	2.45 (1.26–4.77)	.009
Model 2, OR (95% CI)§	Reference	2.81 (1.30–6.07)	.008

* Participants who had Hearing Handicap Inventory for the Elderly Screening scores of 10 or more were considered to have hearing handicap.
† Score >5 on the 15-item Geriatric Depression Scale.
‡ Adjusted for age, sex, education level, living circumstances, smoking status, alcohol drinking, past and current history of major illness, and measured vision impairment.
§ Also measured hearing impairment.
OR = odds ratio, CI = confidence interval.

DISCUSSION

This community-based cohort study showed that hearing handicap assessed according to the HHIE-S is clearly associated with the future occurrence of depressive symptoms. In the literature, some cross-sectional studies have indicated that hearing impairment is associated with mental state in clinical[7] or field settings,[8] but several recent cross-sectional field studies in which hearing impairment was evaluated with audiometry found no association between hearing impairment and depressive symptoms.[9,10] To the best of the knowledge of the authors of the current article, this is the first longitudinal study to confirm that hearing handicap can predict depressive symptoms.

It has been said that auditory tests fail to identify what kind of hearing difficulties people have.[11,12] Pure-tone audiometers assess only the minimum sound intensity level someone can perceive. They do not assess, for example, the ability to catch speech, which such factors as the speaker's pronunciation, the way they speak, and ambient noise affect. Moreover, auditory tests cannot assess the emotional distress of hearing-impaired people, who social and communication troubles with their families and other people strongly affect. These factors may well explain why several studies in which hearing impairment was assessed using audiometers failed to find any association between hearing impairment and depressive symptoms.[9,10]

By contrast, HHIE-S was developed to assess the difficulties that a hearing-impaired individual may experience in a variety of situations, together with the psychosocial effect of hearing impairment.[11] HHIE-S includes questions about real-life situations (e.g., "Does a hearing problem cause you difficulty when listening to TV or radio?" "Does a hearing problem cause you difficulty when in a restaurant with relatives or friends?") and the subject's emotional states (e.g., "Does a hearing problem cause you to feel embarrassed

when meeting new people?" "Does a hearing problem cause you to feel frustrated when talking to members of your family?").[11] The severity of hearing impairment as evaluated using an audiometer was associated with self-reported communication difficulties and activities of daily living (ADLs), but self-reported hearing handicap evaluated using the HHIE-S correlated more closely with impaired ADLs and QOL as assessed using the Medical Outcomes Study 36-item Short Form Survey scores than with audiometric results.[26] Impaired ADLs and QOL are directly associated with mental health, including depression.[27] Thus, although auditory tests may be useful to some extent for evaluating the effect of hearing impairment on mental health, they cannot be fully relied on. The results of the current study, which indicate that hearing handicap is a better predictor of future depressive symptoms and that the prevention of hearing handicap may be a useful strategy for preventing depression in older people, seem to be more reliable.

The use of hearing aids can reverse the adverse effects of hearing impairment on QOL in elderly people,[28] but because hearing aids simply adjust sound intensity and do not restore normal hearing, providing hearing aids is not enough to improve hearing handicaps and prevent depressive symptoms induced by ARHL. For good hearing rehabilitation, the emphasis should be on giving people proper information about hearing impairment, gradually introducing them to hearing aid use, and teaching hearing strategies (e.g., lip reading, nonverbal signals, asking others to speak more clearly).[29] The HHIE scores of older people with hearing impairment who were given education programs in communication improved after 1 year; no significant changes were observed in the control group.[30] In addition, communication is a two-way process; the burden of communication falls equally on the speaker and listener. For older people, the key people in their lives are the family members they live with and their close friends. Therefore, effective education for the families and friends of older people with hearing impairment is probably also necessary for good communication to be achieved. To prevent the induction of depressive symptoms by hearing impairment, healthcare strategies for ARHL must include education about the nature of hearing impairment and proper hearing aid use, and such education must be given not only to people with hearing impairments themselves, but also to their families, friends, and even all community-dwelling people. It is hoped that the validity of this belief will be confirmed in further intervention studies.

Despite the strengths of the present study (the use of standardized audiometric techniques and well-documented self-reporting questionnaires, taking many potential confounders into consideration, and its longitudinal design), there are also some limitations. First, because of the field setting nature of this study, hearing impairment was assessed only at a single sound frequency. Second, depressive symptoms were assessed using a questionnaire and were not confirmed by a psychiatrist. Therefore, caution is necessary in applying the results to clinical situations.

In conclusion, this study supports the hypothesis that hearing handicap can be used as a predictor of future depressive symptoms in older community-dwelling people and suggests that the social and emotional conditions of people with hearing impairment have an important bearing on their mental health.

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Author Contributions: Hideyuki Saito, Yuji Nishiwaki, and Toru Takebayashi: study design, data collection, data analysis, interpretation of data, and preparation of the manuscript. Takehiro Michikawa and Yuriko Kikuchi: data collection, data analysis, and review of drafts of the article. Kunio Mizutari and Kaoru Ogawa: interpretation of data as an otorhinolaryngologist and review of drafts of the article. All authors approved the final version of the article.

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REFERENCES

1. Davis AC. The prevalence of hearing impairment and reported hearing disability among adults in Great Britain. Int J Epidemiol 1989;18:911–917.
2. Gates GA, Cooper JC Jr, Kannel WB et al. Hearing in the elderly: The Framingham cohort, 1983–1985. Part 1. Basic audiometric test results. Ear Hear 1990;11:247–256.
3. Cruickshanks KJ, Wiley TL, Tweed TS et al. Prevalence of hearing loss in older adults in Beaver Dam, Wisconsin. The Epidemiology of Hearing Loss Study. Am J Epidemiol 1998;148:879–886.
4. Sindhusake D, Mitchell P, Smith W et al. Validation of self-reported hearing loss. The Blue Mountains Hearing Study. Int J Epidemiol 2001;30:1371–1378.
5. Uchida Y, Nakashima T, Ando F et al. Prevalence of self-perceived auditory problems and their relation to audiometric thresholds in middle-aged to elderly population. Acta Otolaryngol 2003;123:618–626.
6. Gates GA, Mills JH. Presbycusis. Lancet 2005;366:1111–1120.
7. Singerman B, Riender E, Folstein M. Emotional disturbance in hearing clinic patients. Br J Psychiatry 1980;137:58–62.
8. Herbst KG, Humphrey C. Hearing impairment and mental state in the elderly living at home. BMJ 1980;281:903–905.
9. Chou KL. Combined effect of vision and hearing impairment on depression in older adults: Evidence from the English Longitudinal Study of Ageing. J Affect Disord 2008;106:191–196.
10. Tambs K. Moderate effects of hearing loss on mental health and subjective well-being: Results from the Nord-Trøndelag Hearing Loss Study. Psychosom Med 2004;66:776–782.
11. Ventry IM, Weinstein BE. The hearing handicap inventory for the elderly: A new toll. Ear Hear 1982;3:128–134.
12. Noble W. Assessment of Impaired Hearing. A Critique and a New Method. New York: Academic Press, 1978.
13. Ewertsen HW, Birk-Nielsen H. Social hearing handicap index. Social handicap in relation to hearing impairment. Audiology 1973;12:180–187.
14. Giolas TG, Owens E, Lamb SH et al. Hearing performance inventory. J Speech Hear Disord 1979;44:169–195.
15. Lichtenstein MJ, Bess FH, Logan SA. Validation of screening tools for identifying hearing-impaired elderly in primary care. JAMA 1988;259:2875–2878.
16. Lichtenstein MJ, Hazuda HP. Cross-cultural adaptation of the Hearing Handicap Inventory for Elderly-Screening Version (HHIE-S) for use with Spanish-speaking Mexican Americans. J Am Geriatr Soc 1998;46:492–498.
17. Michikawa T, Ishida S, Nishiwaki Y et al. Serum antioxidants and age-related macular degeneration among older Japanese. Asia Pac J Clin Nutr 2009;18:1–7.
18. Michikawa T, Nishiwaki Y, Kikuchi Y et al. Serum levels of retinol and other antioxidants for hearing impairment among Japanese older adults. J Gerontol A Biol Sci Med Sci 2009;64A:910–915.
19. Harada S, Nishiwaki Y, Michikawa T et al. Gender difference in the relationships between vision and hearing impairments and negative well-being. Prev Med 2008;47:433–437.

20. Hoyl MT, Alessi CA, Harker JO et al. Development and testing of a five-item version of the Geriatric Depression Scale. J Am Geriatr Soc 1999;47:873–878.
21. Reyes-Ortiz CA, Kuo YF, Dinuzzo AR et al. Near vision impairment predicts cognitive decline: Data from the Hispanic established populations for epidemiologic studies of the Elderly. J Am Geriatr Soc 2005;53:681–686.
22. Munoz B, West SK, Rubin GS et al. Causes of blindness and visual impairment in a population of older Americans: The Salisbury Eye Evaluation Study. Arch Ophthalmol 2000;118:819–825.
23. Okamoto M, Nakanishi N, Tatara K. Self-reported hearing difficulty and hearing impairment in Japanese people living in a community. Int J Audiol 2004;43:54–59.
24. Sheikh JI, Yesavage JA. Geriatric Depression Scale (GDS): Recent evidence and development of a short version. Clin Gerontol 1986;5:165–173.
25. Buchner DM, Hornbroo MC, Kutner NG et al. Development of the common data base for the FICSIT trials. J Am Geriatr Soc 1993;41:297–308.
26. Dalton DS, Cruickshanks KJ, Klein BE et al. The impact of hearing loss on quality life in older adult. Gerontologist 2003;43:661–668.
27. Parker SG, Bechinger-English D, Jagger C et al. Factors affecting completion of the SF-36 in older people. Age Aging 2006;35:376–381.
28. Mulrow CD, Aguilar C, Endicott JE et al. Quality-of-life changes and hearing impairment. A randomized trial. Ann Intern Med 1990;113: 188–194.
29. Dillon H. Counseling the new hearing aid wearer. In: Dillon H. Hearing Aids. Sydney: Boomerang Press, 2001, pp 322–348.
30. Hickson L, Worrall L. Beyond hearing aid fitting: improving communication for older adults. Int J Audiol 2003;42(Suppl 2):84–91.

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Brief Original Report

Tinnitus preceded depressive symptoms in community-dwelling older Japanese: A prospective cohort study

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ABSTRACT

Objective. Most studies of the association between tinnitus and depression have been cross-sectional, making it difficult to draw any conclusions about the directionality of the association. This study aimed to clarify whether tinnitus precedes the development of depressive symptoms in a general older population.

Methods. Residents of Kurabuchi Town, Gunma Prefecture, Japan (239 men, 296 women: ≥65 years) without depressive symptoms were given health examinations in 2005–2006. Information on tinnitus was obtained via a questionnaire. Depressive symptoms were then assessed in a face-to-face home visit interviews carried out once in 2007 and once in 2008 according to the Geriatric Depression Scale 15-item version (GDS15).

Results. Among the men, the 2.5-year incidence of depressive symptoms (GDS15≥6) was higher in those with tinnitus than in those without (20.5% vs. 9.5%). In the multi-adjusted model, tinnitus was significantly associated with an increased risk of depressive symptoms (relative risk=2.07; 95% confidence interval=1.01–4.25). Among the women, no associations were found.

Conclusion. In the present study, tinnitus was independently associated with the risk of depressive symptoms developing in men, but not in women. We believe primary care providers and public health staff should recognize tinnitus as a risk factor for depressive symptoms.

Introduction

Tinnitus, defined as the perception of sound without external auditory stimulus (Lockwood et al., 2002), is closely associated with depression (Langguth et al., 2011), but the cross-sectional design of earlier studies has limited the conclusions that can be drawn about the temporality of the association, i.e. whether tinnitus precedes depression. In older adults, tinnitus is a relatively common complaint, with prevalence estimated to be more than 10% (Ahmad and Seidman, 2004). Depression has a strong negative impact on well-being (Reynolds et al., 2012), so primary prevention of depression is desirable from a public health point of view. Given the association of tinnitus with depression (Langguth et al., 2011; Michikawa et al., 2010) and many treatment modalities to improve symptoms of tinnitus (Seidman et al., 2010), it is important to establish whether the association is a causal one, i.e. whether tinnitus is a risk factor of depression. Therefore, we attempted to establish a causal link between tinnitus and depressive symptoms in a community-based study of older Japanese.

Methods

Study population

Between 2005 and 2006, all residents aged 65 years or older of Kurabuchi Town, Gunma Prefecture, Japan, excluding those hospitalized or institutionalized, were enrolled in a cohort study (The Kurabuchi Study); 834 of them (64.5%) participated in the baseline health examinations (Michikawa et al., 2012, 2013; Saito et al., 2010). Of these, the 549 participants (244 men, 305 women) with no depressive symptoms (Geriatric Depression Scale [GDS] 5-item version≤1) at baseline were questioned about whether they had tinnitus. The protocol was approved by the Keio University Ethics Review Board, and written informed consent was obtained from all participants.

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Measures

Because tinnitus is a subjective experience, the subjects were classified as having tinnitus or not on the basis of their response ("Yes" or "No") to the following single question (Michikawa et al., 2010): "Have you experienced any ringing, buzzing or other sounds (tinnitus) in your ears within the past year?"

Face-to-face home-visit interviews were performed once in 2007 and once in 2008. Trained public health nurses and local welfare commissioners collected information on depressive symptoms according to the GDS15-item version (score: 0–15), one of the most useful and well-validated questionnaire for older populations (Sheikh and Yesabage, 1986). Subjects choose yes or no answers to questions asking how they felt over the past week. In the present study, participants with scores of 6 or more in either 2007 or 2008 were considered depressed (Michikawa et al., 2012; Saito et al., 2010).

Statistical analysis

Of the 549 participants, outcome information was obtained on 535 (239 men, 296 women); 9 of the other 14 had died, 4 had been admitted to nursing homes or hospitals, and 1 (0.2%) was lost to follow-up. Thus, we analyzed 535 participants to determine the association between tinnitus and depressive symptoms. Stata version 11 (StataCorp) was used to perform the statistical analysis.

We found moderate evidence of interaction between tinnitus and sex (p for interaction = 0.10), so all analyses were performed after stratification by sex. Poisson regression with robust error variance (Zou, 2004) was used to estimate the relative risks (RRs) with 95% confidence intervals (CIs) of depressive symptoms associated with tinnitus. In Model 1, we adjusted for age (continuous), hearing impairment, and hearing handicap, which are the factors strongly associated with tinnitus (Gopinath et al., 2010; Michikawa et al., 2010). For hearing impairment, subjects were categorized into 2 groups according to their ability to hear a 30 dB HL signal at 1 kHz in the better ear (Saito et al., 2010), because daily conversation in Japanese relies more on low-frequency signals than on high-frequency signals (Okamoto et al., 2004). We defined hearing handicap as a score of ≥10 in the Hearing Handicap Inventory for Elderly: Screening version (Lichtenstein et al., 1988). In Model 2, self-reported history of coronary heart disease, knee joint pain, vision impairment, and serum levels of dehydroepiandrosterone-sulfate were adjusted for. These covariates were previously found to be associated with tinnitus or depressive symptoms (Harada et al., 2008; Michikawa et al., 2012; Saito et al., 2010).

Results

Table 1 summarizes the baseline characteristics of the participants with or without tinnitus by sex. In both men and women, those with tinnitus were more likely to have hearing impairment and hearing handicap; the men with tinnitus were also more likely to use hearing aids than those without. No differences in the distribution of the other variables were found in relation to tinnitus.

During the average follow-up period of 2.5 years, the cumulative incidence of depressive symptoms was 20.5% among men with tinnitus, and 9.5% among those without (Table 2). The men with tinnitus had a statistically significant increased risk of depressive symptoms (Model 2: RR = 2.07; 95% CI = 1.01–4.25), which persisted after further adjustments and restricted analyses. Conversely, no association between tinnitus and depressive symptoms was observed in women.

Discussion

As far as we know, only one study of older community-based subjects has longitudinally examined the association between tinnitus and depressive symptoms (Gopinath et al., 2010). However, that study did not consider depressive symptoms at baseline, so ours is the first to present data on the temporal association between tinnitus and depressive symptoms in a general older population.

We observed a sex-specific association between tinnitus and depressive symptoms. A recent physiological study showed a different response to tinnitus between men and women in the orbitofrontal cortex, an important region for the emotional processing of sounds (Vanneste et al., 2012), so a sex-specific association is perhaps not surprising. However, it is still not entirely clear why we observed an association between tinnitus and depressive symptoms only in men.

Table 1
Baseline characteristics (2005–2006) of participants in the Kurabuchi Study.

Variables	Tinnitus	Men (n = 239)		*P*-value[a]	Women (n = 296)		*P*-value[a]
		No (n = 200) number (%)	Yes (n = 39) number (%)		No (n = 248) number (%)	Yes (n = 48) number (%)	
Age (years)	65–69	46 (23.0)	10 (25.6)	.73	61 (24.6)	11 (22.9)	.97
	70–79	111 (55.5)	19 (48.7)		130 (52.4)	26 (54.2)	
	80–	43 (21.5)	10 (25.6)		57 (23.0)	11 (22.9)	
Educational level	Elementary or junior high school	135 (69.6)	27 (69.2)	.97	180 (73.5)	38 (80.9)	.29
Living circumstances	Alone	13 (6.6)	2 (5.1)	.73	34 (14.1)	6 (12.8)	.82
Social activities	None/occasional	80 (41.0)	17 (43.6)	.77	135 (55.3)	26 (56.5)	.88
Current smoker	Yes	52 (26.5)	8 (20.5)	.43	7 (2.9)	1 (2.1)	.78
Current alcohol drinker	Yes	110 (56.4)	25 (64.1)	.38	30 (12.3)	5 (10.9)	.79
Vision impairment[b]	Yes	31 (15.5)	10 (25.6)	.12	73 (29.4)	9 (18.8)	.13
Hearing impairment[c]	Yes	28 (14.0)	10 (25.6)	.07	49 (19.8)	14 (29.8)	.12
Hearing handicap[d]	Yes	41 (20.8)	18 (44.7)	<.01	33 (13.4)	15 (31.3)	<.01
Hearing aid usage	Yes	5 (2.5)	3 (7.7)	.10	7 (2.8)	1 (2.1)	.79
Functional activities[e]	Reduced	13 (6.7)	4 (10.3)	.43	24 (9.9)	3 (6.4)	.45
Cognitive function[f]	Impaired	23 (11.5)	8 (20.5)	.13	45 (18.2)	8 (16.7)	.80
Serum levels of dehydroepiandrosterone-sulfate (μmol/L)[g]		2.22 (1.78)	2.36 (1.63)	.56	1.35 (1.94)	1.23 (2.67)	.35
History of diabetes[h]	Yes	46 (24.0)	11 (28.1)	.58	35 (14.5)	7 (14.9)	.95
Self-reported history of stroke	Yes	16 (8.4)	3 (7.9)	.92	14 (5.8)	1 (2.1)	.30
Self-reported history of coronary heart disease	Yes	19 (10.0)	7 (18.4)	.14	20 (8.3)	4 (8.5)	.97
Self-reported history of cancer	Yes	8 (4.2)	2 (5.3)	.76	7 (2.9)	1 (2.1)	.76
Knee joint pain in the last year	No pain	124 (63.9)	21 (53.9)	.36	139 (56.5)	22 (46.8)	.24

[a] The chi-square test or Student *t*-test.
[b] Vision impairment was defined as a corrected visual acuity of worse than 0.5 in the better eye.
[c] Subjects were classified as belonging to the hearing impairment group if they failed to hear the 30 dB HL signal at 1 kHz in the better ear.
[d] Hearing handicap was defined as a score of ≥10 in the 10-item screening version of Hearing Handicap Inventory for Elderly.
[e] Reduced functional activities were defined as a score of ≤10 in the Tokyo Metropolitan Institute of Gerontology Index of Competence.
[f] Cognitive impairment was defined as a score of ≤3 in the Clock-Drawing Test.
[g] Geometric mean (geometric standard deviation).
[h] Diabetes was defined as self-reported and/or hemoglobin of A_{1c} ≥ 5.8%.

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Table 2
The 2.5-year incidence of depressive symptoms caused by tinnitus in the community-dwelling Japanese older adults: the Kurabuchi Study, 2005–2008.

Tinnitus	Men (n = 239)		*P*-value	Women (n = 296)		*P*-value
	No (n = 200)	Yes (n = 39)		No (n = 248)	Yes (n = 48)	
Incidence (%)	9.5	20.5		19.0	18.8	
Age-adjusted RR (95% CI)	Reference	2.18 (1.08–4.42)	.03	Reference	0.93 (0.49–1.77)	.83
Model 1[a], RR (95% CI)	Reference	2.15 (1.06–4.35)	.03	Reference	0.84 (0.42–1.67)	.61
Model 2[b], RR (95% CI)	Reference	2.07 (1.01–4.25)	.04	Reference	0.89 (0.43–1.84)	.76
Model 2 + social factors[c], RR (95% CI)	Reference	2.19 (1.01–4.72)	.05	Reference	0.88 (0.43–1.83)	.74
Model 2 + lifestyle[d], RR (95% CI)	Reference	2.12 (1.00–4.47)	.05	Reference	0.92 (0.45–1.91)	.83
Model 2 + history of major illnesses[e], RR (95% CI)	Reference	2.05 (0.99–4.23)	.05	Reference	0.90 (0.43–1.87)	.78
Model 2 + functional activities and cognitive function[f], RR (95% CI)	Reference	2.25 (1.06–4.77)	.04	Reference	1.00 (0.48–2.10)	.99
Model 2 excluding subjects using hearing aids[g], RR (95% CI)	Reference	2.32 (1.12–4.80)	.02	Reference	0.89 (0.40–1.95)	.77
Model 2 excluding subjects with severe hearing impairment[h], RR (95% CI)	Reference	2.44 (1.13–5.28)	.02	Reference	0.84 (0.39–1.80)	.65

RR: relative risk; CI: confidence interval.
[a] Adjusted for age (continuous), hearing impairment (yes, no), and hearing handicap (yes, no).
[b] Model 1 + self-reported history of coronary heart disease (yes, no), knee joint pain in the last year (no pain, pain without medical consultation, pain requiring medical consultation), vision impairment (yes, no), and serum levels of dehydroepiandrosterone-sulfate (quartiles).
[c] Model 2 + educational level (elementary or junior high school, high school or higher), living circumstances (alone or with spouse/family/others), and social activities (none/occasional, regular/constant).
[d] Model 2 + smoking status (current smoker or not) and alcohol drinking (current drinker or not).
[e] Model 2 + history of diabetes (yes, no), and self-reported history of stroke (yes, no) and/or cancer (yes, no).
[f] Model 2 + functional activities (reduced or not) and cognitive function (impaired or not).
[g] Model 2 excluding subjects using hearing aids (8 men, 9 women) because hearing aids are sometimes used to treat tinnitus.
[h] Model 2 excluding subjects with severe hearing impairment (23 men, 30 women) as a failure to hear a 50 dB HL signal at 1 kHz to avoid psychological effect by social isolation.

Cross-sectional studies have not revealed this sex-specific association (Michikawa et al., 2010; Vanneste et al., 2012). One possible explanation is that persistent (chronic) tinnitus, which is more common in men because of hearing impairments caused by occupational noise exposure (Palmer et al., 2002), can lead to depressive symptoms. We did not assess the persistence of tinnitus, so further studies are required to investigate this factor.

The present study points to the need for new strategies to combat tinnitus as a way of preventing depression in community-dwelling older adults. Prevention would provide broad public health benefits, because depression has various negative effects on well-being, such as reduced quality of life, impaired functional activities, and suicide thoughts (Fiske et al., 2009). Tinnitus is a common complaint, so if it is confirmed as a risk factor for depression, effective screening and management will be important in preventing depression. Screening for tinnitus can be done simply with the question we used in our survey. Although there is no single effective treatment for tinnitus, various measures can improve symptoms. For example, the alleviation of hearing difficulties with hearing aids or cochlear implants, tinnitus retraining therapy, masking therapy, and transcranial magnetic stimulation are known to have beneficial effects (Seidman et al., 2010).

The present study has several strengths: negligible loss to follow-up, the use of an internationally accepted and well-validated questionnaire (GDS), and our ability to adjust for various confounding factors. This was a prospective cohort study, so we were able to exclude subjects with depressive symptoms at baseline. However, baseline screening was done with GDS5 rather than GDS15, so depressive symptoms might have been underestimated. Therefore, the possibility of reverse causation cannot be completely ruled out in the association between tinnitus and depressive symptoms. In addition, we cannot exclude the possibility of unmeasured and residual confounding. Further studies are required to firmly establish whether tinnitus has a causal association with depressive symptoms.

Conclusions

We conclude that tinnitus is associated with an increased risk of incident depressive symptoms in Japanese community-dwelling older men, but not in older women. We believe primary care providers and public health staff should recognize tinnitus as a risk factor for depressive symptoms.

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Conflict of interest statement

The authors declare that there are no conflicts of interests.

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The authors' responsibilities were as follows: TM originated the study and contributed to the study design, the statistical analysis, and the writing of the article. YN helped conceptualized the study and contributed to the study design, the statistical analysis, and the interpretation of the data. HS and KM helped conceptualized the study and interpreted the data. TT contributed to data analysis and interpretation of data. All authors provided significant editing of the article and approved the final manuscript.

References

Ahmad, N., Seidman, M., 2004. Tinnitus in the older adult: epidemiology, pathophysiology and treatment options. Drugs Aging 21, 297–305.
Fiske, A., Wetherell, J.L., Gatz, M., 2009. Depression in older adults. Annu. Rev. Clin. Psychol. 5, 363–389.
Gopinath, B., McMahon, C.M., Rochtchina, E., Karpa, M.J., Mitchell, P., 2010. Risk factors and impacts of incident tinnitus in older adults. Ann. Epidemiol. 20, 129–135.
Harada, S., Nishiwaki, Y., Michikawa, T., et al., 2008. Gender difference in the relationships between vision and hearing impairments and negative well-being. Prev. Med. 47, 433–437.
Langguth, B., Landgrebe, M., Kleinjung, T., Sand, G.P., Hajak, G., 2011. Tinnitus and depression. World J. Biol. Psychiatry 12, 489–500.
Lichtenstein, M.J., Bess, F.H., Logan, S.A., 1988. Validation of screening tools for identifying hearing-impaired elderly in primary care. JAMA 259, 2875–2878.
Lockwood, A.H., Salvi, R.J., Burkard, R.F., 2002. Tinnitus. N. Engl. J. Med. 347, 904–910.
Michikawa, T., Nishiwaki, Y., Kikuchi, Y., et al., 2010. Prevalence and factors associated with tinnitus: a community-based study of Japanese elders. J. Epidemiol. 20, 271–276.
Michikawa, T., Nishiwaki, Y., Nakano, M., et al., 2012. Higher serum dehydroepiandrosterone sulfate levels are protectively associated with depressive symptoms in men,

but not in women: a community-based cohort study of older Japanese. Am. J. Geriatr. Psychiatry (Oct 4., Epub ahead of print).
Michikawa, T., Nishiwaki, Y., Asakura, K., et al., 2013. Sunlight exposure may be a risk factor of hearing impairment: a community-based study in Japanese older men and women. J. Gerontol. A Biol. Sci. Med. Sci. 68, 96–103.
Okamoto, M., Nakanishi, N., Tatara, K., 2004. Self-reported hearing difficulty and hearing impairment in Japanese people living in a community. Int. J. Audiol. 43, 54–59.
Palmer, K.T., Griffin, M.J., Syddall, H.E., Davis, A., Pannett, B., Coggon, D., 2002. Occupational exposure to noise and the attributable burden of hearing difficulties in Great Britain. Occup. Environ. Med. 59, 634–639.
Reynolds III, C.F., Cuijpers, P., Patel, V., et al., 2012. Early intervention to reduce the global health and economic burden of major depression in older adults. Annu. Rev. Public Health 33, 123–135.
Saito, H., Nishiwaki, Y., Michikawa, T., et al., 2010. Hearing handicap predicts the development of depressive symptoms after 3 years in older community-dwelling Japanese. J. Am. Geriatr. Soc. 58, 93–97.
Seidman, M.D., Standring, R.T., Dornhoffer, J.L., 2010. Tinnitus: current understanding and contemporary management. Curr. Opin. Otolaryngol. Head Neck Surg. 18, 363–368.
Sheikh, J.I., Yesabage, J.A., 1986. Geriatric depression scale (GDS) recent evidence and development of a shorter version. Clin. Gerontol. 5, 165–173.
Vanneste, S., Joos, K., De Ridder, D., 2012. Prefrontal cortex based sex differences in tinnitus perception: same tinnitus intensity, same tinnitus distress, different mood. PLoS One 7 (e31182).
Zou, G., 2004. A modified poisson regression approach to prospective studies with binary data. Am. J. Epidemiol. 159, 702–706.

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