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Association between speech and high-frequency hearing loss and depression, anxiety and stress in older adults

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ABSTRACT

Background: Age-related hearing loss (ARHL) and depression are considered leading causes of disability in older adults. This cross-sectional study investigated the association between the severity of speech and high-frequency ARHL and depression, anxiety and stress in older adults.
Study design: Cross-sectional study of a community-derived sample of adult volunteers.
Methods: A hearing assessment was completed by 151 participants (73 males and 78 females; M = 64.44 ± 10.77 years). Based on their better-ear speech (0.5, 1, 2, & 4 kHz) and high-frequency (6 & 8 kHz) hearing thresholds, they were divided three groups: those with normal hearing; those with mild to moderate hearing loss; and those with moderately severe to profound hearing loss. All participants also completed the Depression, Anxiety and Stress Scale (DASS-21).
Results: A binomial logistic regression analysis revealed that the respective odds ratios (ORs) (95% confidence interval) of clinically significant depression, anxiety and stress for participants with a moderately severe to profound hearing loss across the speech frequency range were: 27.51 (3.25, 232.95), 5.89 (1.95, 17.73) and 5.64 (1.55, 20.48). Similarly, the respective ORs of clinically significant depression, anxiety and stress were 6.54 (0.75, 57.02), 6.21 (1.52, 25.33) and 5.32 (1.02, 27.75) for participants with moderately severe to profound hearing loss across high frequencies. The non-parametric Cuzik test revealed a statistically significant positive ($p < .05$) trend of association between both better-ear speech and high-frequency hearing loss and DASS scores.
Conclusion: The observed graded associations suggest that hearing loss is a causative factor for clinically significant depression, anxiety and stress symptoms.

1. Introduction

More than one third of the world population above the age of 65 years suffers from a greater than 40 dB hearing loss in the better hearing ear and this age-related hearing loss (ARHL) is regarded as one of the most ubiquitous and debilitating heath conditions of our time [1]. Globally, more than 320 million people suffer from depression and more than 260 million people suffer from anxiety disorders [2]. Together with ARHL, depression and anxiety are considered one of the leading causes of disability worldwide [2]. The risk factors for late life depression, anxiety and stress seem to overlap with those associated with ARHL [3]. Throughout this manuscript collectively 'depression, anxiety and stress symptoms' have been referred to as 'mental health'. This paper specifically examines whether the severity of both speech and high frequency hearing impairment is associated with mental health outcomes of older adults.

ARHL is associated with a multitude of dire outcomes including increased risk of cognitive impairment [4], dementia [5,6] and Alzheimer's disease [5], reduced quality of life [7], incident falls [8,9], low level of physical activity [10], frailty [11] and slow gait speed [12]. ARHL has also been associated with higher prevalence of social isolation [13], depression [14–16] anxiety [4,17] and stress [4].

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Several studies have reported the association between depression and hearing loss. Kalayam et al. [18] observed that the age of depression onset was associated with speech frequency hearing loss (0.5–4 kHz) in 43 participants diagnosed with unipolar major depression. Furthermore, 85% of adults with sensorineural hearing loss greater than 40 dB at 1 and 2 kHz in one ear, or 1 or 2 kHz in both ears, showed evidence of clinically significant depressive symptoms [18]. Kalayam et al. [18] demonstrated a significant difference ($p < 0.001$) in the severity of sensorineural hearing loss in subjects who had onset of depression after the age of 55 years compared with participants who had depressive symptoms before the age of 55 years, suggesting that hearing loss could play a role in the causation of depression in later life. Depression, in turn, has been associated with loneliness [19], self-reported physical health [19], cardiovascular disease [20], functional impairment [21], increases the risk of developing irreversible dementia [22] and mortality [23].

Mehta et al. [17] reported that anxiety symptoms are observed more in people with than without depressive symptoms. Ressler and Mayberg [24] reported that depression and anxiety disorders not only have a similar underlying aetiology but also respond to the same intervention strategies. Further, anxiety is associated with numerous physical and psychological conditions, including hearing loss [4], hypertension [17], sleep insufficiency [17,25], fair or poor general health [25], and unhealthy behaviours such as smoking, high alcohol consumption, obesity, and physical inactivity [25].

A relationship between onset of depression and stressful life events have been reported [26,27]. Moreover, psychological stress is reported to be associated with duration, symptom exacerbation, and relapse of major depressive episodes [26]. Psychological stress is associated with cardiovascular [28] and inflammatory diseases [29]. It could also trigger unhealthy lifestyle choices such as excessive alcohol consumption [30] and visceral obesity [31].

There are overlapping central neurological, anatomical and physiological processes that result in mental health and ARHL. Neuroimaging studies have reported a decline in hippocampal [32,33], prefrontal cortical [34] and amygdala [35] volumes in those diagnosed with depression. Those diagnosed with anxiety disorders without comorbid depression have shown decreased regional grey matter volumes in cingulate, frontal, middle temporal and precentral gyri [36]. Further, exaggerated activities in amygdala and hippocampus in response to anxiety provoking stimuli have also been observed in those with social anxiety disorders [37]. In stress disorders involvement of both sympathetic [38] and hypothalamic-pituitary-adrenal-stress (HPA axis) – via glucocorticoid (GC) mechanism [39], and a decline in volume hippocampal and medial frontal lobe volumes and increased amygdala responsivity [40] have been reported.

The cortical and subcortical structures that are adversely affected by depression, stress and anxiety are implicated in ARHL as well. Hearing loss leads to pathophysiological changes in both peripheral and central auditory pathways [41]. Neuroimaging studies on ARHL have demonstrated a decline in grey matter volume in temporal gyri [42], frontal gyri [42,43], primary auditory cortex [44,45], and hypothalamus [43]. These findings suggest that ARHL and mental health symptoms perhaps share a common neuro-pathophysiological pathways and functions. In summary, the pathophysiological changes of cortical and sub-cortical structures observed in those with age-related hearing loss seem to overlap with cortical-subcortical changes observed in those with mental health symptoms. Hence, they may facilitate the expression of one-another.

Importantly, most of the audiological studies that have investigated the association between ARHL and mental health in older adults have employed either self-reported hearing loss questionnaires [13,16] or pure-tone average hearing threshold testing between 0.5–4 kHz [3,7,46].This is interesting because epidemiological data on ARHL suggest that ARHL is initially observed first in the high frequencies > 4 kHz which, with time, later progresses to also include the 2–4 kHz range [47]. Hence it would be informative to assess whether there is an association between speech frequency (0.5–4 kHz) and high frequency hearing loss (6–8 kHz) and mental health. Furthermore, it would be useful to know whether this initial high frequency hearing loss can predict the depression, anxiety or stress at an earlier stage before speech frequency loss is evident. Our cross sectional study investigated whether the severity of both speech and high frequency hearing impairment is associated with mental health outcomes of older adults.

2. Methods

2.1. Study design & setting

Cross-sectional study of a community-derived sample of adult volunteers in contact with clinical services of the Ear Science Institute Australia in Perth, Western Australia.

2.2. Participants

We used radio and newspaper advertisements, as well as the clinical services of the Ear Science Institute Australia Hearing Implant Centre, to recruit participants. 151 volunteer male and female participants, either native or fluent English speakers, aged between 40 and 88 years with bilateral symmetrical pure-tone audiometric thresholds completed the study protocol. 48 of the 151 participants were recruited from the clinical services of the Ear Science Institute Australia and 103 responded to the advertisements. The Human Research Ethics Committee of the University of Western Australia approved the study protocol (RA/4/1/7368) and all participants provided written informed consent.

2.3. Materials and procedure

The assessment materials included measures of hearing ability as well as depression, anxiety and stress.

2.3.1. Hearing assessment

Pure-tone audiometric assessment (MIDIMATE 602 Audiometer, GN Otometrics Ltd, Sydney) was carried out in a sound-proof room by a qualified Audiologist. Bilateral air conduction thresholds between 0.5-8 kHz and bone conduction thresholds between 0.5- 4 kHz were obtained using pure-tone audiometry. Better ear air conduction thresholds across 0.5–4 kHz were averaged (BE 4PTA) and better ear air conduction thresholds at 6 and 8 kHz were averaged (BE HF 2PTA) for the statistical analysis of the study. Based on BE 4PTA the participants were divided into three groups: normal hearing (NH) ≤ 25 dBHL, mild-moderate hearing loss (MMH) 26dBHL and 55 dBHL and moderately-severe to profound hearing loss (MSPH) > 55 dBHL [48]. Due to the small sample size mild and moderate categories and moderately-severe, severe and profound categories were combined. Similarly, the participants were divided into three groups based on their BE HF 2PTA scores: (HFNH) ≤ 25 dBHL, mild-moderate hearing loss (HFMMH) 26dBHL and 55 dBHL and moderately-severe to profound hearing loss (HFMSPH) > 55 dBHL.

2.3.2. Assessment of depression, anxiety and stress

The Depression Anxiety Stress Scales: DASS-21 [49] was used to measure the severity (past seven days) of a range of symptoms common to depression, anxiety and stress. It uses a 4-point combined severity/frequency scale to rate the extent to which the participant has experienced each question/statement over the past week. Each test item is scored from 0 (never – did not apply to me at all over the last week) to 3 (almost always – applied to me very much most of the time over the past week). Seven statements are used to assess each of the three mental health domains, with total sub-scores for depression, anxiety and stress calculated by summing the scores for the relevant items and multiplying them by two (×2), so that each sub-score can range from 0 to 42