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Hearing loss and gait speed among older adults in the United States

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ABSTRACT

Background: Previous studies have suggested that hearing loss, which is highly prevalent but undertreated in older adults, may be associated with gait and physical functioning. Determining if hearing loss is independently associated with gait speed is critical toward understanding whether hearing rehabilitative interventions could help mitigate declines in physical functioning in older adults.

Methods: We analyzed cross-sectional data from the 1999 to 2002 cycles of the National Health and Nutritional Examination Survey during which participants 50–69 years ($n = 1180$) underwent hearing and gait speed assessments. Hearing was defined by a pure tone average of hearing thresholds at 0.5–4 kHz tones in the better-hearing ear. Gait speed was obtained in a timed 20-ft (6.1 m) walk. Linear and logistic regression models were used to examine the association between hearing loss and gait speed while adjusting for demographic and cardiovascular risk factors. Analyses incorporated sampling weights to yield results generalizable to the U.S. population.

Results: In a model adjusted for demographic and cardiovascular risk factors, a hearing loss was associated with slower gait speed (−0.05 m/s per 25 dB of hearing loss [95% CI: −0.09 to −0.02]) and an increased odds of having a gait speed <1.0 m/s (OR = 2.0 per 25 dB of hearing loss, 95% CI: 1.2–3.3). The reduction in gait speed associated with a 25 dB hearing loss was equivalent to that associated with an age difference of approximately 12 years.

Conclusions: Greater hearing loss is independently associated with slower gait speed. Further studies investigating the mechanistic basis of this association and whether hearing rehabilitative interventions could affect gait and physical functioning are needed.

1. Introduction

Walking constitutes a complex task that requires the coordinated functioning of multiple organ systems, and, therefore, gait speed is considered a robust indicator of health status [1,2]. Previous studies have explored the roles of biological, cognitive, and social determinants in predicting gait speed decline. Increasingly, measures of cognitive performance including executive functioning have been found to be associated with gait speed [3–5].

While hearing loss has not been previously considered a risk factor for slower gait speed, hearing loss is associated with several conditions such as increased cognitive load [6], poorer executive functioning [7,8], and reduced social and physical functioning [9] that could plausibly promote slower gait speed. Alternatively, hearing loss and gait speed may be linked through concomitant cochlear and vestibular dysfunction or a shared pathologic etiology such as from microvascular disease. Hearing loss is highly prevalent [10] yet remains vastly undertreated in older adults [11]. Determining if hearing loss is independently associated with gait speed is an important first step toward understanding whether hearing rehabilitative interventions could possibly help mitigate declines in physical functioning.

The objective of the current study was to examine the cross-sectional association between hearing loss and gait speed in a nationally representative sample of adults aged 50–69 years. We investigated whether greater hearing loss was associated with reduced gait speed obtained in a 20-ft (6.1 m) timed walk. We hypothesized a priori that greater hearing loss as measured by pure tone audiometry is associated with slower gait speed after adjustment for potential confounders.

2. Methods

2.1. Study subjects

Subjects for this study were participants (age 50–69 years) who completed both the audiometric examination and timed 20-ft walk

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in the 1999–2002 cycles of the National Health and Nutritional Examination Survey (NHANES), an ongoing program of studies designed to assess the health, functional, and nutritional status of the United States civilian non-institutionalized population. From 1999 to 2002, audiometry was administered to a half sample of all adults 20–69 years, and gait speed was assessed in participants 50 years and older. No subsequent NHANES cycles have concurrently assessed both hearing loss and gait speed. Each sequential cross-sectional study in NHANES uses a stratified, multistage probability sampling design to survey a sample of the population, with selective oversampling of low-income individuals, racial minorities, and older adults [12]. Sampling weights allow for analyses that account for the complex sampling survey and yield results that are generalizable to the U.S. population. De-identified data available within public domain, as provided by NHANES, were used for the study. The NHANES protocol (#98–12) was reviewed and approved by the National Center for Health Statistic's Institutional Review Board (IRB) and documented informed consent was obtained from all participants.

2.2. Audiometric assessment

Audiometry was performed by a trained examiner according to established NHANES protocols [13]. Briefly, a trained examiner obtained air conduction hearing thresholds from both ears in a dedicated, sound-isolating room in a mobile examination center. Testing was conducted according to a modified Hughson Westlake procedure using the automated testing mode of the audiometer (Interacoustics AD226) and/or manually per the testing protocol. Quality assurance and quality control were established through daily calibration of equipment and monitoring of ambient noise levels using a sound level meter. The audiometric test room met or exceeded ANSI S3.1-1991 guidelines for maximum permissible ambient noise levels. Air conduction stimuli were presented primarily through supra-aural earphones (TDH 39P). Insert earphones (ER3A) were reserved for cases of collapsing ear canals or for a cross-over retesting protocol in cases of asymmetric hearing loss (masking was not performed). As an additional quality measure, thresholds were measured twice at 1 kHz in both ears, and audiometry was repeated if there was >10 dB discrepancy between the threshold measurements. We utilized hearing thresholds from 0.5 to 4 kHz, using the first threshold tested at 1 kHz and incorporating manual re-test thresholds as needed. Hearing loss was defined as a speech-frequency pure tone average (PTA) of thresholds at 0.5, 1, 2, and 4 kHz in the better hearing ear in accordance with the World Health Organization [14]. Categories of hearing loss severity were based on American Speech-Language Hearing Association guidelines [15], but several categories were collapsed to simplify analyses (normal hearing ≤25 dB, mild loss >25 dB and ≤40 dB, moderate loss >40 dB and ≤70 dB, severe loss >70 dB). All hearing thresholds are reported as dB HL, which is a standard audiometric measurement used to assess the level of hearing loss.

2.3. Gait speed assessment

Gait speed was obtained with a timed 20-foot (6.1 meter) walk, as administered per the NHANES protocol [16]. Briefly, participants were instructed to walk at their usual pace, with the use of a walker or cane if needed, along a designated 20-ft long test track area in the MEC. A certified health technician used a hand-held stopwatch to measure the time from when the participant's first foot touched the floor beyond the start line to when his or her foot touched the floor across the 20-ft finish line. Gait speed was calculated by dividing the walking distance (20 ft = 6.10 m) by the time (seconds) needed to complete the walk. Individuals with a history of myocardial infarction within the past six weeks, chest or abdominal surgery within the past three weeks, knee surgery or knee replacement surgery, severe back pain, a history of brain aneurysm or stroke, and/or inability to walk without holding onto someone were excluded from gait speed testing. Quality assurance and quality control were established through monitored site visits, procedural checklists, and continuous data review for identifying systematic errors.

2.4. Covariates

Data on demographic variables and medical history were obtained from interviews. Self-reported race/ethnicity was grouped as Mexican-American/other Hispanic (Hispanic), non-Hispanic white (white), non-Hispanic black (black), or other race. Education was collapsed into a 4 level variable (less than high school, high school graduate, some college, or college graduate). We adjusted for race and education because they may be associated with both hearing loss and health status and therefore could be potential confounders. Hearing aid use was based on whether an individual with hearing loss reported using a hearing aid at least once a day over the preceding year. Variables related to medical history included diabetes (based on self-reported diagnosis and/or current use of insulin or other diabetic medications), smoking (current/former/never), hypertension (told by physician on two or more visits about hypertension diagnosis), and stroke (self-reported history).

2.5. Statistical methodology

We accounted for the complex sampling design in all analyses by using sample weights according to National Center for Health Statistics (NCHS) guidelines [17] except for Table 1. The purpose of Table 1 was only to give descriptive statistics on the characteristics of the study cohort rather than nationally generalizable estimates and hence weights were not used. Locally weighted scatterplot smoothing (lowess) was used to graphically explore the association of hearing loss and age with gait speed and to identify non-linear data trends and outliers. Based on the lowess plot, two participants with gait speed >2 m/s were identified as outliers and were excluded from further analyses. We also excluded participants with gait speed <0.6 m/s ($n = 40$) to limit the analysis to non-frail individuals [18]. We used linear and logistic regression models to analyze whether hearing loss was associated with slower gait speed, after adjusting for age and other covariates. The β-coefficients from linear regressions are interpreted as the average difference in gait speed (i.e. negative values indicate slower gait speed) associated per unit change in hearing loss and age. A sensitivity analysis was also performed to normalize the gait speed variable with respect to standing height (normalized speed $= \text{speed} \times 1/\sqrt{\text{Height} \times g}$), where height is measured in meters and $g = 9.81\ \text{m/s}^2$) [19,20]. Per NCHS guidelines, the Taylor Series Linearization method was used for variance estimation. All analyses were conducted using STATA 12 (StataCorp, College Station, TX).

3. Results

Table 1 summarizes the demographic characteristics of the study population. From 1999 to 2002, 1180 participants aged 50–69 years underwent concurrent assessments of hearing loss and gait speed in NHANES. Hearing loss > 25 dB was prevalent in 23.0% of these participants, and among those with hearing loss, hearing aids were used by 4.4%. The vast majority of participants had hearing thresholds in the normal-to-mild range with only 5.2% of participants having a moderate or greater hearing loss. The mean