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Research Article

Association of Hearing Impairment with Declines in Physical Functioning and the Risk of Disability in Older Adults

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Abstract

Background: Identifying factors associated with functional declines in older adults is important given the aging of the population. We investigated if hearing impairment is independently associated with objectively measured declines in physical functioning in a community-based sample of older adults.

Methods: Prospective observational study of 2,190 individuals from the Health, Aging, and Body Composition study. Participants were followed annually for up to 11 visits. Hearing was measured with pure-tone audiometry. Physical functioning and gait speed were measured with the Short Physical Performance Battery (SPPB). Incident disability and requirement for nursing care were assessed semiannually through self-report.

Results: In a mixed-effects model, greater hearing impairment was associated with poorer physical functioning. At both Visit 1 and Visit 11, SPPB scores were lower in individuals with mild (10.14 [95% CI 10.04–10.25], $p < .01$; 7.35 [95% CI 7.12–7.58], $p < .05$) and moderate or greater hearing impairment (10.04 [95% CI 9.90–10.19], $p < .01$; 7.00 [95% CI 6.69–7.32], $p < .01$) than scores in normal hearing individuals (10.36 [95% CI 10.26–10.46]; 7.71 [95% CI 7.49–7.92]). We observed that women with

moderate or greater hearing impairment had a 31% increased risk of incident disability (Hazard ratio [HR] =1.31 [95% CI 1.08–1.60], p < .01) and a 31% increased risk of incident nursing care requirement (HR = 1.31 [95% CI 1.05–1.62], p = .02) compared to women with normal hearing.
Conclusions: Hearing impairment is independently associated with poorer objective physical functioning in older adults, and a 31% increased risk for incident disability and need for nursing care in women.

Key Words: Physical function—Physical performance—Epidemiology.

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The prevalence of hearing impairment doubles with every age decade such that nearly two-thirds of adults aged 70 and older in the United States have a clinically significant hearing impairment that hinders daily communication (1). Recent epidemiologic studies have demonstrated that hearing impairment is independently associated with poorer physical functioning (2,3) and falls (4,5) in older adults. These associations may be explained by concomitant vestibular dysfunction, (6,7) a shared pathologic etiology (eg microvascular disease; inflammation), or through the effects of hearing impairment on cognitive load, (8,9) social isolation, (10) and reduced awareness of the auditory environment.

Maintaining an optimal level of physical functioning is a critical aspect of healthy aging, and objective physical performance tests predict the onset of dependence and mortality in older adults (11). Currently, there are no longitudinal studies that examine whether hearing impairment is associated with poorer objective physical functioning in older adults. Identifying potentially modifiable risk factors for poorer physical functioning in the elderly is a critical public health priority given the aging of the population.

In this study, we investigate whether hearing impairment is independently associated with declines in physical functioning in older adults. We use a well-established physical performance battery to assess objective physical functioning over an 11-year period. To better understand the clinical and public health significance of these results, we also investigate the association of hearing impairment with the risk of incident disability and requirement for nursing care.

Methods

Study Population

Participants were enrolled in the Health, Aging and Body Composition (Health ABC) study, a prospective observational study of 3,075 well-functioning, community-dwelling older adults aged 70–79 years from 1997 to 1998 (12,13). Study participants were recruited from a random sample of White and Black Medicare beneficiaries living within predesignated zip codes in Pittsburgh, PA and Memphis, TN that were within a 1-h drive of the examination sites. Only White and Black individuals were recruited because an original study objective was to examine race differences in body composition parameters, and there were insufficient resources to include other races or ethnicities. To be eligible, participants had to report no difficulty with walking a quarter mile, climbing 10 steps without resting, or performing basic activities of daily living at enrollment.

Our analytic cohort consisted of all study participants (n = 2,190) who had audiometric testing performed at Visit 5 (audiometric testing was not performed at Visit 1). Compared to these individuals who received audiometric testing, participants who did not return for Visit 5 and therefore did not receive audiometric testing were more likely to be older, Black, less educated, from the Memphis study site, and to have a stroke history. All study participants signed a written informed consent, and this study was approved by the institutional review boards of the study sites.

Audiometry

Audiometric assessments were performed at Visit 5 with the participant in a sound attenuating booth and the examiner outside the booth. Air-conduction thresholds were obtained for each ear at octave frequencies from 0.25 to 8 kHz with a portable audiometer (Maico MA40) and supra-aural earphones (TDH 39). The booth and audiometer were calibrated with the prevailing American National Standards Institute standards for hearing threshold testing. All thresholds were measured in decibels hearing level (dB HL). A four-frequency pure tone average (PTA) of hearing thresholds obtained at 0.5, 1.0, 2.0, and 4 kHz was calculated for the better ear. Mild hearing impairment was defined as a PTA >25 and ≤40 dB HL, and moderate or greater hearing impairment was defined as a PTA >40 dB HL per World Health Organization definitions (14).

Physical Functioning

The Established Populations for Epidemiologic Studies of the Elderly Short Physical Performance Battery (EPESE SPPB) was administered to participants at Visits 1, 4, 6, 10, and 11 of the study. The number of participants in our analytic cohort with SPPB data available at each visit, categorized by level of hearing impairment, is presented in Supplementary Table 1. The SPPB measures physical performance in three categories: gait speed, standing balance, and chair stands, each on a scale of 0–4. Cutoffs for each four-point scale were determined by quartile performance in the initial EPESE study (11). Gait speed, expressed in meters per second, was measured as time to walk a 3, 4, or 6-m walking course at a comfortable pace. For tests of standing balance, participants attempted to maintain a side-by-side, semi-tandem, and full-tandem stand for 10 s each and received a scaled score based on ability to perform each stand. Finally, chair stands were measured as the amount of time it took for a participant to completely stand up and sit down from a chair five times without using his or her arms for assistance. The four-point scales in each category were added to create a 12-point summary score for the SPPB, with higher scores indicating better physical performance. For our analyses, we used the composite SPPB summary score, as well as gait speed in meters/second.

In addition to objective performance data, we also analyzed adjudicated self-report data on incident physical disability and need for nursing care gathered from interviewer-administered questionnaires every 6 months. For physical disability, the outcome of interest was time from baseline (Visit 1) to any self-reported disability, which was defined as severe difficulty or inability to walk 1/4 mile and/or climb 10 steps, needing equipment to ambulate, or having any difficulty performing activities of daily living (ie getting in and out of bed or chairs, bathing or showering, and dressing) (15). For nursing care needs, the outcome of interest was time from baseline to a self-reported overnight admission to a nursing home, or requirement for home nursing care.

Other Covariates

We adjusted for variables (eg, age, demographic, and cardiovascular risk factors) that could potentially confound the association of hearing impairment with physical functioning. At enrollment, participants reported their age, sex, race, and highest level of education attained. Pre-specified algorithms based on both self-report and physician diagnoses, recorded medications, and laboratory data were used to define presence of hypertension (based on clinic measure, medications, or self-report) and diabetes mellitus (based on fasting blood glucose level, medications, or self-report). Stroke history and smoking status (current/former/never) were based on interviewer-administered questionnaires. Cardiovascular risk factors as well as self-reported hearing aid use were determined at Visit 5.

Statistical Analyses

Baseline characteristics of the study participants were compared using the Wilcoxon rank-sum test and Fisher's exact test where appropriate. Linear mixed effects (LME) models were used to assess the association between hearing impairment and longitudinal changes in physical function. Random effects were used to model inter-individual heterogeneity in both baseline level and annual rates of change in physical function. In LME models, interactions between hearing impairment and time were included to assess the association between hearing impairment and longitudinal changes in physical function. Hearing impairment was specified as a categorical variable (normal hearing [PTA ≤ 25 dB HL], mild hearing impairment [PTA >25 and ≤40 dB HL], and moderate or greater hearing impairment [>40 dB HL]) in all analyses. In order to determine whether hearing aid use acted as a potential moderator in the relationship between hearing impairment and physical function, an indicator of hearing aid use and its interaction with time was included in LME models estimated using the subset of individuals with mild or greater hearing impairment. Regression assumptions were checked with residual plots and histograms. We also conducted a sensitivity analysis using only physical functioning data gathered after hearing testing was performed at Visit 5 to ensure that earlier physical performance data gathered before Visit 5 were not biasing the findings.

Cox proportional hazards (PH) models were used to assess the association of hearing impairment with incident disability and incident need for nursing care. The assumption of proportional hazards was evaluated using the correlation coefficient between transformed survival time and the scaled Schoenfeld residuals, and models were stratified by sex and study site to achieve proportionality of the hazard functions. Tied survival times were handled using Efron's method.

The LME and PH models were adjusted for demographic factors (age, sex, race, and education) and cardiovascular risk factors (history of smoking, hypertension, diabetes, and stroke at Visit 5) as time-constant covariates. Participants with any missing covariate data (n = 16, <1% of the analytic cohort in all analyses) were excluded from analyses. All significance tests were conducted using two-sided tests with a type I error rate of 0.05. LMEs models were estimated in SAS 9.3 (SAS Institute, Cary, NC) using PROC MIXED, and Cox Proportional Hazards were estimated using in R 2.15.2 (R Foundation for Statistical Computing, Vienna, Austria) using the Survival package (Therneau, 2012). Statistical significance was specified as a two-sided $p < .05$.

Results

A total of 2,190 participants were included in our analysis. The demographic and clinical characteristics of the study cohort, categorized by degree of hearing impairment, are presented in Table 1. Participants with hearing impairment were more likely to be older, White, male, enrolled at the Memphis site, and have a positive smoking history than participants with normal hearing. Participants with normal hearing, mild hearing impairment, and moderate or greater hearing impairment had mean PTAs of 18.2 (SD = 5.0) dB HL, 32.5 (SD = 4.3) dB HL and 50.4 (SD = 9.1) dB HL, respectively.

In a mixed-effects model adjusted for demographic and cardiovascular risk factors, we observed non-linear declines in SPPB scores that accelerated over time for all hearing groups over the 11-year study period (Figure 1a). Compared to mean baseline (Visit 1) SPPB scores in normal hearing individuals (10.36 [95% CI 10.26–10.46]), baseline SPPB scores were significantly lower in those with mild (10.14 [95% CI 10.04–10.25], $p < .01$) and moderate or greater hearing impairment (10.04 [95% CI 9.90–10.19], $p < .01$). At Visit 5, there was no significant difference in SPPB scores among the three groups. However, at Visit 11 scores were lower in those with mild (7.35 [95% CI 7.12–7.58], $p < .05$) and moderate or greater hearing impairment (7.00 [95% CI 6.69–7.32], $p < .01$) compared to normal hearing individuals (7.71 [95% CI 7.49–7.92]). In Table 2, we present estimated means for time points at Visits 1, 5, and 11 estimated from our multivariate mixed-effects model. These time points were chosen to demonstrate differences in SPPB scores at the beginning, middle, and approximate midpoint of the study.

The mixed effects model for gait speed demonstrated a similar pattern of decline in gait speed that accelerated over time for all hearing groups over the study period (Figure 1b). Individuals with *moderate or greater hearing impairment* had significantly slower gait speeds than participants with normal hearing at Visit 1 (1.18 [95% CI 1.16–1.21] vs 1.22 [95% CI 1.20–1.23], $p < .05$), Visit 5 (1.08 [95% CI 1.06–1.10] vs 1.11 [95% CI 1.09–1.13], $p < .05$), and Visit 11 (0.80 [95% CI 0.77–0.84] vs 0.88 [95% CI 0.86–0.91], $p < .01$). The adjusted mean gait speed was not significantly different for individuals with mild hearing impairment versus normal hearing at any of these visits (Table 2).

Additional analyses stratified by sex demonstrated no significant moderation of the association between hearing impairment and accelerated declines in SPPB scores or gait speed by sex (data not shown). We also conducted a sensitivity analysis using only physical functioning data gathered after hearing testing was performed at Visit 5 to ensure that earlier physical performance data gathered before Visit 5 were not biasing the findings. These results demonstrated a similar pattern of results with mild and moderate or greater hearing impairment at Visit 5 being associated with lower SPPB scores and gait speed compared to Visits 6 to 11 in fully-adjusted models (Supplementary Figure 1).

We next investigated whether the association of hearing impairment with objective measures of physical functioning also extended to real-world indicators of physical functioning such as incident disability and incident need for nursing care. Compared to individuals with normal hearing, individuals with a moderate or greater hearing

Table 1. Demographic and Clinical Characteristics of Study Cohort* by Hearing Impairment Status†

Characteristic	Normal Hearing (n = 908)	Mild Hearing Impairment (n = 829)	Moderate or Greater Hearing Impairment (n = 453)	p value
Age, mean (*SD*), y	73.3 (2.7)	74.2 (2.8)	74.9 (2.9)	<.001
Race				<.001
Black	421 (46.4)	278 (33.5)	115 (25.4)	
White	487 (53.6)	551 (66.5)	338 (74.6)	
Male	348 (38.3)	406 (49.0)	294 (64.9)	<.001
Education				.009
<12th grade	192 (21.1)	166 (20.0)	129 (28.5)	
High school graduate	297 (32.7)	284 (34.2)	135 (29.8)	
Some college or greater	419 (46.1)	379 (45.7)	189 (41.7)	
Site				.005
Memphis	405 (44.6)	405 (48.9)	244 (53.9)	
Pittsburgh	503 (55.4)	424 (51.1)	209 (46.1)	
Smoking				<.001
Current	53 (5.8)	49 (5.9)	35 (7.7)	
Former	397 (43.7)	413 (49.8)	248 (54.7)	
Never	458 (50.4)	367 (44.3)	170 (37.5)	
Hypertension	709 (78.1)	638 (77.0)	349 (77.0)	.833
Diabetes	161 (17.7)	161 (19.4)	103 (22.7)	.089
Stroke	61 (6.7)	81 (9.8)	50 (11.0)	.013
PTA	18.2 (5.0)	32.5 (4.3)	50.4 (9.1)	<.001
Hearing aid use	5 (0.6)	71 (8.6)	200 (44.2)	<.001

Notes: PTA, pure tone average; *SD*, standard deviation.

*Hearing status, smoking, hypertension, diabetes, and stroke defined/measured at Visit 5.

†All values are expressed as no. (%) of participants unless otherwise indicated. Hearing is defined by a four-frequency pure tone average (PTA) of thresholds obtained at 0.5, 1, 2, and 4 kHz in the better hearing ear. Mild hearing impairment was defined as PTA > 25 and ≤40 dB HL, and moderate or greater impairment was defined as PTA >40 HL.

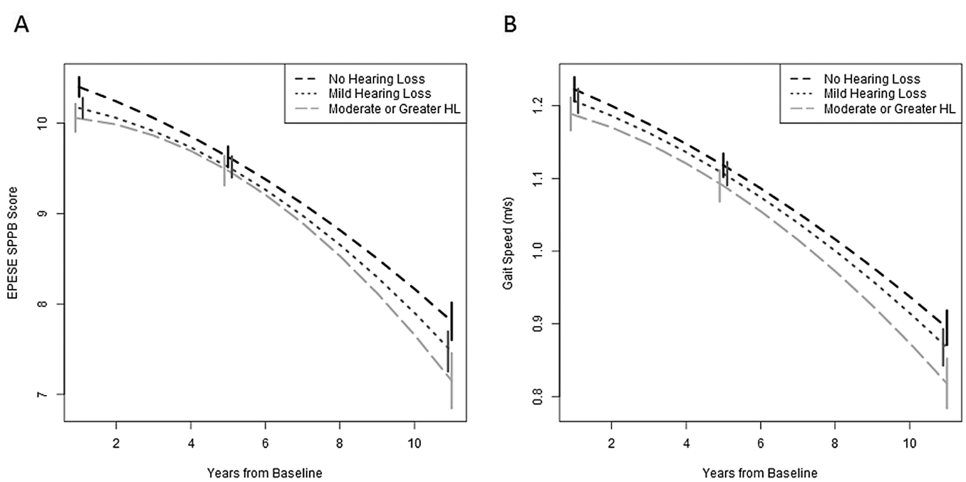

Figure 1. Trajectories of decline in (a) SPPB summary score and (b) gait speed according to hearing status.

impairment had a 25% (HR = 1.25 [95% CI 1.09–1.40], p < .01) increased risk of incident disability in fully-adjusted proportional hazard models. Similar results were observed for incident nursing requirement. Compared to individuals with normal hearing, individuals with a moderate or greater hearing impairment had an 18% (HR = 1.18 [95% CI 1.01–1.37], p = .03) increased risk of requiring nursing care. Analyses stratified by sex demonstrated stronger associations between hearing impairment and incident disability as well as need for nursing care need in women than in men (Figure 2). Compared to women with normal hearing, women with moderate or greater hearing impairment had a 31% increased risk (HR = 1.31 [95% CI 1.08–1.60], p < .01) of incident disability and a 31% increased risk (HR = 1.31 [95% CI 1.05–1.62], p = .02) of incident nursing care requirement. In this stratified model, there were no significant associations between hearing impairment and either incident disability or need for nursing care in men (Table 3).

Finally, we also investigated whether hearing aid use among individuals with hearing impairment was associated with physical performance trajectories and incident disability and nursing care requirement. In these fully adjusted analyses restricted to individuals with mild or greater hearing impairment, we found that individuals who used hearing aids had SPPB scores and gait speeds at Visits 1, 5, and 11 that were not

Table 2. Estimated Mean SPPB Summary Score and Gait Speed at Visits 1, 5, and 11 for Individuals with Normal Hearing, Mild Hearing Impairment, and Moderate or Greater Hearing Impairment‡ From Multivariate Mixed-Effects Models§

		Visit 1	Visit 5	Visit 11
SPPB summary score (95% CI)	Normal hearing	10.36 (10.26–10.46)	9.56 (9.44–9.68)	7.71 (7.49–7.92)
	Mild hearing impairment	10.14† (10.04–10.25)	9.45 (9.33–9.57)	7.35* (7.12–7.58)
	Moderate or greater hearing impairment	10.04† (9.90–10.19)	9.41 (9.24–9.58)	7.00† (6.69–7.32)
Gait speed (m/s) (95% CI)	Normal hearing	1.22 (1.20–1.232)	1.11 (1.09–1.13)	0.88 (0.86–0.91)
	Mild hearing impairment	1.20 (1.19–1.22)	1.10 (1.08–1.11)	0.85 (0.83–0.88)
	Moderate or greater hearing impairment	1.18* (1.16–1.21)	1.08* (1.06–1.10)	0.80† (0.77–0.84)

Notes: CI = confidence interval.

*$p < .05$; †$p < .01$ compared to normal hearing.

‡Based on a four-frequency pure tone average of hearing thresholds obtained at 0.5, 1, 2, and 4 kHz in the better hearing ear at Visit 5. Mild hearing impairment is defined as pure tone average >25 and ≤40 dB HL. Moderate or greater hearing impairment is defined as pure tone average >40 dB HL.

§All models are adjusted for age, sex, race, education, study site, smoking status, hypertension, diabetes, and stroke.

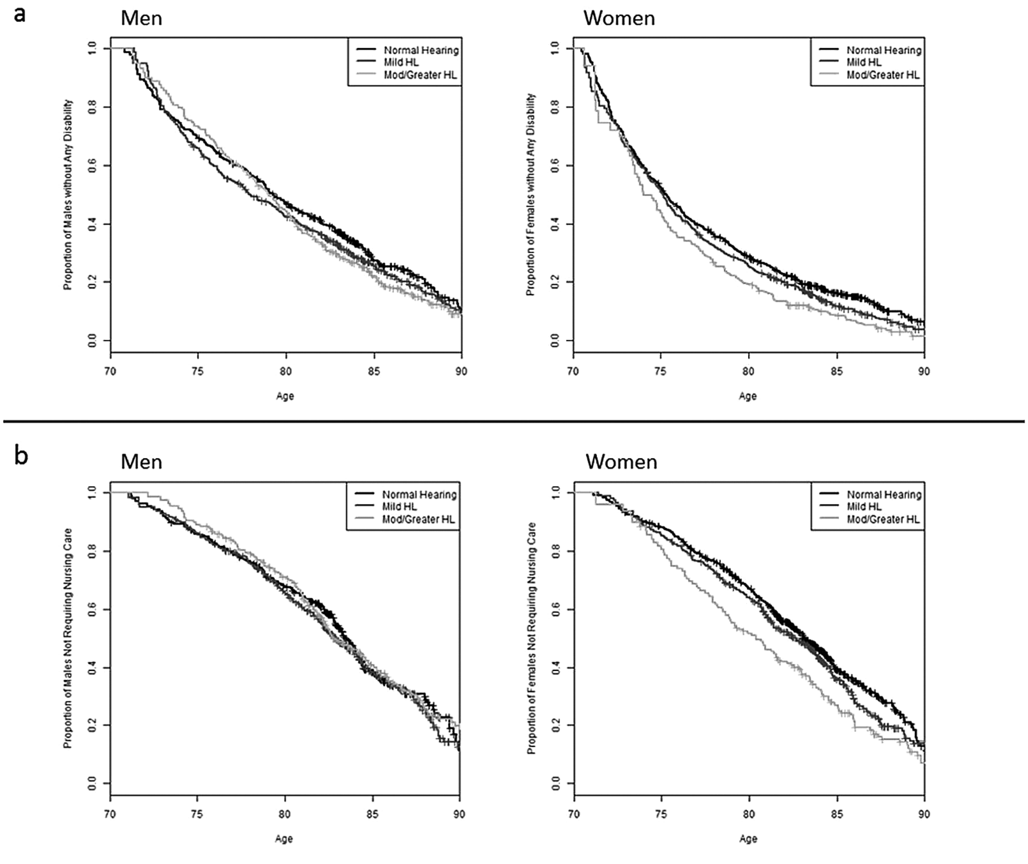

Figure 2. Kaplan–Meier survival curves of (**a**) incident disability and (**b**) incident nursing care requirement for men (n = 1,048) and women (n = 1,142).

significantly different than individuals not using hearing aids (data not shown). We also did not observe any significant attenuation in the risk of incident disability (HR = 0.98 [95% CI 0.84–1.15]) or need for nursing care (HR = 0.90 [95% CI 0.75–1.07]) associated with hearing aid use.

Discussion

Our results demonstrate that hearing impairment in older adults is independently associated with poorer physical functioning over a 10-year follow-up period, as well as a 31% increased risk of incident disability and need for nursing care in women. We observed a "dose-dependent" effect with greater levels of hearing impairment being associated with poorer function over time and greater risk for incident disability. Our results were robust to adjustment for multiple potential confounders and sensitivity analyses. These findings demonstrate that audiometrically measured hearing impairment, a highly prevalent condition in older adults (1), is independently associated with poorer objective physical functioning that is reflected in important real world outcomes such as risk of disability and need for nursing care.

Prior longitudinal studies on the association of hearing impairment with incident functional decline have had inconsistent results,

Table 3. Cox Proportional Hazards of Incident Self-Reported Disability and Nursing Care Requirement for Individuals with Mild or Moderate/Greater Hearing Impairment‡ Compared to Normal Hearing

		All Individuals§ (n = 2,190)	Men Only (n = 1,048)‖	Women Only (n = 1142)¶
Incident disability (95% CI)	Mild hearing impairment	1.11 (0.99–1.24)	1.15 (0.96–1.37)	1.11 (0.96–1.28)
	Moderate or greater hearing impairment	1.25† (1.09–1.43)	1.21 (0.99–1.46)	1.31† (1.08–1.60)
Incident nursing requirement (95% CI)	Mild hearing impairment	1.12 (0.99–1.27)	1.13 (0.93–1.38)	1.09 (0.93–1.29)
	Moderate or greater hearing impairment	1.18* (1.01–1.37)	1.09 (0.88–1.35)	1.31* (1.05–1.62)

Notes: CI = confidence interval.

*$p < .05$; †$p < .01$ compared to normal hearing.

‡Based on a four-frequency pure tone average of hearing thresholds obtained at 0.5, 1, 2, and 4 kHz in the better hearing ear at Visit 5. Mild hearing impairment is defined as pure tone average >25 and ≤40 dB HL. Moderate or greater hearing impairment is defined as pure tone average >40 dB HL.

§Left-truncated proportional hazards model using age as the time scale. Sex and site were incorporated in the baseline hazard for incident disability and diabetes and site were incorporated in the baseline hazard for incident nursing requirement to maintain proportional hazard assumptions.

‖Left-truncated proportional hazards model for males, stratified by site. Age is modeled in the nonparametric base hazard function.

¶Left-truncated proportional hazards model for females. Hypertension was incorporated in the baseline hazard for incident disability and diabetes and site were included in the baseline hazard for incident nursing requirement. Age is modeled in the nonparametric base hazard function.

with some studies demonstrating a positive association (2–4) and others finding no significant association (16–19). This heterogeneity in study results is likely explained by differences in how hearing [eg subjective self-report (3,16,17) vs objective clinical audiometry (2,4,18,19)] and physical functioning [eg activities of daily living (2,3,16,17), walking difficulty (19), falls (4), or other self-reported measures (2,3,18)] were measured. Biased or imprecise assessments of hearing thresholds would likely decrease the sensitivity to detect associations due to increased variance. Furthermore, prior studies have only used self-reported subjective measures of physical functioning. Strengths of this study include the use of a standardized audiometric testing protocol, objective assessments of physical performance, and clinically significant indicators of physical performance such as incident disability and requirement for nursing care.

We found that individuals with greater hearing impairment on average had poorer SPPB scores and slower gait speeds at two times points 10 years apart which were also reflected in an increased risk of incident disability and need for nursing care in women. SPPB score and gait speed are well-validated, widely used measures of physical functioning for older adults, (11,20–23) predictive of self-reported disability, (21) hospitalization, (24,25) nursing home admission and survival (11,26,27). Interestingly, while greater hearing impairment was associated with poorer objective physical functioning in both men and women, we only observed a strong association between greater hearing impairment and indicators of real world physical functioning (incident disability and need for nursing care) in women. The basis of this finding is unclear and will require further investigation.

Several explanations could potentially account for the observed association between hearing impairment and functional decline. A shared impairment of the cochlear and vestibular sense organs, given their common location in the inner ear, (7,28) could plausibly contribute to impaired balance and poorer physical functioning. However, a previous study demonstrated associations between hearing impairment and falls that were robust to adjustment for vestibular function (5). Hearing impairment as measured with pure tone audiometry is also weakly associated with cardiovascular risk factors, (29,30) and underlying microvascular disease or another common aging process (eg inflammation 31) could possibly underlie the association of hearing impairment and poorer physical functioning.

Hearing impairment could also be associated with physical functioning through mechanistic pathways involving effects of hearing impairment on cognitive load, social isolation, and reduced awareness of the auditory environment. Age-related hearing impairment leads to impaired neural encoding of sounds by the cochlea, and the increased cognitive resources required for processing of degraded sound signals may place a greater burden on the listener's cognitive and attentional resources, (9,32) both of which are important determinants of physical mobility and functioning. Consistent with this hypothesis, hearing impairment has been associated with poorer performance on tests of executive function requiring attentional resources, (33–35) which are necessary for maintaining postural control and balance (36,37) and predict gait speed declines in older adults (38,39). Communication impairments due to hearing impairment may also contribute to social isolation and loneliness in older adults, (3,10) which in turn could mediate the association with poorer physical functioning (40,41). Finally, hearing impairment may deprive the listener of auditory cues which aid in mobility, and this decreased awareness of the auditory environment could further impact physical functioning.

In this study, self-reported hearing aid use was not associated with physical functioning, but data on other key variables (eg hours hearing aid worn per day, number of years used, adequacy of rehabilitation, etc.) that may affect the success of hearing rehabilitation and affect any observed association were not available. Consequently, whether hearing rehabilitative treatments could potentially affect declines in physical functioning will require further investigation.

Our study has limitations. Audiometric testing was performed only at Visit 5, and there is no data available to show changes in hearing before and after that time; however, it is unlikely that this limitation would substantially bias our findings because age-related hearing impairment progresses slowly at a rate of approximately 1–2 dB per year, (22,24) and hearing was conservatively defined using the better hearing ear. A sensitivity analysis using only physical functioning data gathered after hearing testing was also performed with no substantive change in the observed results. We also note that the need for overnight nursing care as measured in this study, while potentially reflecting disability, may also be triggered by important acute events such as a recent hospitalization. Interestingly, a prior study has demonstrated that hearing impairment in older adults is independently associated with odds of hospitalization (42). Residual confounding by unmeasured biological (eg inflammation, microvascular disease), medical, or environmental factors that could contribute to poorer hearing and physical functioning is also a possibility. However, we adjusted for established risk factors for hearing impairment and physical functioning in our models, and we note that these pathways (eg shared pathology, cognitive load, social isolation) are not mutually exclusive and could likely synergistically contribute to poorer physical functioning in individuals with greater hearing impairment. The difference in estimated mean gait speed between those with moderate or greater hearing impairment and those with normal hearing was small (0.03 m/s at Visit 5 and 0.08 m/s at Visit 8). However, Perera et al. (43) found that gait speed differences of 0.05 m/s were clinically meaningful in older adults, suggesting that even small differences in gait speed can be clinically relevant. Finally, we note that informative censoring with mortality is a significant concern in any gerontological longitudinal study (44). Importantly, such a bias would likely lead to overly *conservative* estimates of the association of hearing impairment with declines in physical functioning given that both hearing impairment (45) and physical function (11) are positively associated with mortality.

If confirmed in other independent cohorts, the findings of our study could potentially have substantial implications for public health given the high prevalence of hearing impairment in older adults and the possibility that hearing impairment may be a potentially modifiable, late-life risk factor for physical declines and disability. Further research investigating the mechanistic basis of the observed associations as well as the potential role of hearing rehabilitative therapies in mitigating physical functioning declines in older adults is needed.

Supplementary Data

Supplementary material can be found at http://biomedgerontology.oxfordjournals.org/

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