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Hearing and vision impairment and the 5-year incidence of falls in older adults

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Abstract

Background: concurrent vision and hearing loss are common in older adults; however, epidemiological data on their relationship with the incidence of falls are lacking.
Objective: we assessed the association between dual sensory impairment (DSI) and incidence of falls. We examined the influence of self-perceived hearing handicap and hearing aid use and risk of falls.
Design: a population-based, cohort study of participants followed over 5 years.
Setting: Blue Mountains, west of Sydney, Australia.
Subjects: one thousand four hundred and seventy-eight participants aged 55 and older at baseline were included in longitudinal analyses.
Methods: visual impairment was defined as presenting or best-corrected visual acuity less than 20/40 (better eye), and hearing impairment as average pure-tone air conduction threshold >25 dB HL (500–4,000 Hz, better ear). The shortened version of the hearing handicap inventory for the elderly was administered. Incident falls were assessed over the 12 months before each visit. Cognitive impairment was determined using the Mini-Mental State Examination.
Results: five-year incidence of falls was 10.4%. Participants with severe self-perceived hearing handicap versus no hearing handicap had increased risk of incident falls, multivariable-adjusted OR 1.93 (95% confidence intervals, CI, 1.02–3.64). Hearing aid users versus non-users had 75% increased likelihood of incident falls. Participants with co-existing best-corrected visual impairment and mild hearing loss (>25 to ≤40 dB HL) had higher odds of incident falls, OR 2.19 (95% CI 1.03–4.67). After excluding persons with cognitive impairment, this association did not persist.
Conclusion: these epidemiological data show that DSI in older adults could significantly increase their risk of falling.

Keywords: *Blue Mountains Eye Study, dual sensory impairment, falls, hearing loss, older people, vision loss*

Introduction

Loss of vision and hearing are increasingly frequent problems in ageing populations [1, 2]. Visual and hearing deficits are thought to impair balance control, increase cognitive load that reduces ability to multi-task [3], distract attention from surroundings and contribute to inaccurate assessment of environmental obstacles [4]. Because of age-related sensory and cognitive changes, older people have to allocate more attention, typically with reduced attentional capacity, to maintaining their balance during everyday activities [5].

Published literature concerning the relationship of falls with vision and hearing impairments is inconsistent [6]. While some studies show an increased risk of falling in subjects with hearing [5, 7, 8] and visual impairment [7, 9, 10], other studies do not [11, 12]. There is also a lack of epidemiological data on the temporal association between hearing aid use and self-perceived hearing handicap and incidence of falls. Hearing thresholds do not necessarily correlate with the degree of disability experienced by persons with hearing impairment [13], and we have shown differential associations between audiometric hearing loss, self-perceived hearing handicap and hearing aid use with various health outcomes, e.g. health-related quality of life [14] and activities of daily living [15]. Given these reasons we felt that it was both reasonable and worthwhile to explore these different indicators of impaired hearing and risk of falling. Moreover, only a few studies have assessed the temporal relationship between DSI and incident falls risk. Kulmala *et al.*[16] showed that among older women poor vision accompanied with loss of hearing or balance increased the risk for falls. In contrast, a Nordic clinic-based study of adults aged 75+ found that combined vision and hearing loss was not independently associated with reporting 2 or more falls over 3 months [17].

Given the equivocal findings reported by the above cohort studies on sensory impairment and incidence of falls, and that falls in older adults are an important medical and social problem [4], further studies are needed to establish whether sensory impairments are a prognostic indicator of falls. In this cohort study of adults aged 55 and over, we aimed to answer the following key questions: (i) Is objectively measured hearing loss, self-perceived hearing handicap and/or hearing aid use independently associated with the 5-year incidence of falls? (ii) Does the presence of DSI influence the risk of incident falls over 5 years, after adjusting for potential confounders such as age, sex, walking disability and presence of multiple chronic conditions (e.g. arthritis, diabetes and angina)?

Methods

See Supplementary data, Appendix S1, available in *Age and Ageing* online for full description of the methodology for this study.

Study population

The BMES is a population-based cohort study of common eye diseases and other health outcomes in a suburban Australian population located west of Sydney. Study methods and procedures have been described elsewhere [18].

Audiological assessment

Bilateral hearing impairment was determined as the pure-tone average of audiometric hearing thresholds at 500, 1,000, 2,000 and 4,000 Hz ($PTA_{0.5–4\,kHz}$) in the better ear, defining any hearing loss as $PTA_{0.5–4\,kHz} > 25$ dB HL; mild hearing loss as $PTA_{0.5–4\,kHz} > 25–40$ dB HL; and moderate to severe hearing loss as $PTA_{0.5–4\,kHz} > 40$ dB HL.

Specifically, participants were asked: 'Do you or have you ever worn a hearing aid?' (Yes/No/Don't know). The Hearing Handicap Inventory for the Elderly—Shortened version (HHIE-S), developed by Ventry and Weinstein [19], was also administered.

Assessment of visual impairment

For each eye, visual acuity was recorded as the number of letters read correctly from 0 to 70. For the present study, any visual impairment was defined as presenting or best-corrected visual acuity of the better eye <39 letters (<20/40). DSI was defined as concurrent visual (either presenting or best-corrected) and hearing impairment, as determined using the above definitions.

Assessment of falls

Participants were asked the following question to determine the occurrence of falls over a 12-month period before the study examination; 'During the past 12 months, have there been any falls where you have landed on the ground or floor?' If the response was yes, additional questions were asked, including how many falls they had suffered. We determined the incidence of falls over a 12-month period before each visit among all participants who were examined at the visit. The incidence of falls was categorised into 2 groups; persons who reported 2 or more falls versus persons who reported no falls or only one fall. We chose to categorise falls in this way given that people who have recurrent falls are of greater clinical importance than people who fall less frequently [20].

Statistical analysis

SAS 9.2 software (SAS Institute, Cary, NC, USA) was used for statistical analyses. Baseline characteristics of study participants who were followed over 5 years were compared using *t*-tests and χ^2 tests. The association between hearing loss, hearing handicap, hearing aid use and DSI with 5-year incidence of falls was examined using logistic regression models to estimate odds ratios (OR) and 95% confidence intervals (CI). Multivariable regression models were first adjusted for age (entered as a continuous variable) and sex, and then further adjusted for confounders that were found to be significantly associated with incident falls, i.e. walking disability, 3 or more co-morbidities and visual impairment (when analysing hearing loss, hearing handicap and hearing aid use but not when DSI was the explanatory variable). We tested for statistically significant interactions by adding a product term in the multivariable-adjusted logistic regression models. We tested for an interaction between hearing loss and vision loss on incident falls, and the interactions between DSI and cognitive impairment on risk of falling. We defined an interaction if the influence of, e.g., vision and hearing loss departed from the multiplicative scale of the influence of each impairment alone, confirmed by a statistically significant interaction term ($P < 0.05$).

Results

Of the 1,952 participants examined over 5 years, 1,478 had complete information on the presence of sensory impairments and falls data at baseline and at follow-up. The baseline characteristics of those who were included in longitudinal analyses (n = 1,478) has been described; see Supplementary data, Appendix S2, available in *Age and Ageing* online. Participants with DSI compared with those with no sensory impairment or with a single sensory loss (either best-corrected visual impairment or any level of hearing loss) were more likely to be older, have a walking disability and 3 or more chronic conditions. However, there were more males with hearing loss than with DSI. Five-year incidence of falls (two or more) was 10.4% (n = 153).

There were no significant associations observed between objectively measured hearing impairment and incidence of falls

Table 1. Association between measured hearing loss, hearing handicap inventory for elderly (HHIE) scores and hearing aid use and incidence of falls (two or more)

	Incidence of falls (two or more), OR (95% CI)	
	Age–sex adjusted	Multivariate adjusted[a]
Presence of hearing loss		
No hearing loss (≤25 dB HL), *n* = 867	1.0 (reference)	1.0 (reference)
Any hearing loss (>25 dB HL), *n* = 440	1.41 (0.97–2.06)	1.37 (0.94–2.01)
Severity of hearing loss		
No hearing loss (≤25 dB HL), *n* = 867	1.0 (reference)	1.0 (reference)
Mild hearing loss (26–40 dB HL), *n* = 318	1.35 (0.89–2.03)	1.29 (0.85–1.95)
Moderate to severe hearing loss (>40 dB HL), *n* = 122	1.61 (0.93–2.78)	1.62 (0.93–2.82)
Severity of hearing handicap		
No handicap (HHIE <8), *n* = 802	1.0 (reference)	1.0 (reference)
Moderate handicap (HHIE 8–24), *n* = 372	1.01 (0.68–1.51)	0.97 (0.65–1.46)
Severe handicap (HHIE ≥26), *n* = 79	1.84 (0.98–3.46)	1.93 (1.02–3.64)
Hearing aid use		
No, *n* = 135	1.0 (reference)	1.0 (reference)
Yes, *n* = 1,173	1.76 (1.10–2.84)	1.75 (1.08–2.84)

OR, odds ratio; CI, confidence interval.
[a]Further adjusting for the presence of a walking disability, visual impairment and 3 or more co-morbidities.

Table 2. Association between objectively measured dual sensory impairment and 5-year incidence of falls (two or more) among Blue Mountains Eye Study participants

Visual impairment (<20/40)	Hearing impairment (dB HL)	Incidence of falls (two or more), OR (95% CI)	
		Age–sex adjusted	Multivariate adjusted[a]
No visual impairment	≤25 (No hearing loss), *n* = 772	1.0 (reference)	1.0 (reference)
	>25 (Any hearing loss), *n* = 345	1.42 (0.91–2.22)	1.37 (0.88–2.15)
	>25 to ≤40 (Mild hearing loss), *n* = 258	1.33 (0.82–2.16)	1.27 (0.78–2.07)
	>40 (Moderate–severe hearing loss), *n* = 87	1.75 (0.89–3.48)	1.73 (0.87–3.43)
Presenting	≤25 (No hearing loss), *n* = 185	1.26 (0.73–2.19)	1.25 (0.72–2.17)
	>25 (Any hearing loss), *n* = 167	1.71 (0.99–2.96)	1.70 (0.97–2.96)
	>25 to ≤40 (Mild hearing loss), *n* = 111	1.71 (0.91–3.20)	1.68 (0.90–3.16)
	>40 (Moderate–severe hearing loss), *n* = 56	1.75 (0.79–3.89)	1.79 (0.80–4.01)

OR, odds ratio; CI, confidence interval.
[a]Further adjusting for the presence of a walking disability, visual impairment and three or more co-morbidities.

(2 or more during the 5-year follow-up; Table 1). However, those who experienced significant self-perceived hearing handicap (HHIE-S score ≥26) compared with those with no hearing handicap, had a 93% increased risk of experiencing 2 or more falls over the 5-year follow-up, after multivariable adjustment. Hearing aid users versus non-users at baseline had a 75% increased risk of incident falls 5 years later, after adjusting for all covariates. Non-significant associations were observed among those who had presenting visual impairment and any hearing loss (Table 2). Older adults with moderate to severe hearing loss but no best-corrected visual impairment compared with those with no sensory impairments had a 87% increased likelihood of reporting 2 or more falls at follow-up (Table 3). Participants who had co-existing best-corrected visual impairment and mild hearing loss versus those with no sensory loss at baseline had a 2-fold increased risk of incident falls 5 years later (Table 3). A formal likelihood ratio test demonstrated that the interaction between best-corrected visual impairment and any hearing loss on risk of >2 falls over the 5-year period was non-significant, multivariable-adjusted $P = 0.85$.

There is evidence to suggest that falls risk is related to cognitive impairment in older adults [21, 22]. Therefore, we conducted supplementary analyses where we excluded persons with cognitive impairment as defined by an MMSE score <24, to determine whether the association with sensory impairments and falls risk persists in those with normal cognition. There were only 27 (1.8%) cases of cognitive impairment at baseline, and these were excluded in analyses. In these new analyses, the association between severe hearing handicap and hearing aid use with 5-year incidence of falls persisted, OR 2.07 (95% CI 1.08–3.98) and OR 1.69 (95% CI 1.03–2.79), respectively. However, the association between best corrected visual impairment and mild hearing loss and incident falls became non-significant among those without cognitive impairment, multivariable-adjusted OR 1.89 (95% CI 0.86–4.18).

Further analysis was conducted involving assessing the association between DSI and 5-year incidence of falls, where incidence falls were classified as none versus 1 or more falls over the 5-year period. We found similar associations to what was observed when we compared >2 falls versus 0 or 1 fall. For

Table 3. Association between measured dual sensory impairment and 5-year incidence of falls (two or more) among Blue Mountains Eye Study participants

Visual impairment (<20/40)	Hearing impairment (dB HL)	Incidence of falls (two or more), OR (95% CI)	
		Age–sex adjusted	Multivariate adjusted[a]
No visual impairment	≤25 (No hearing loss), *n* = 893	1.0 (reference)	1.0 (reference)
	>25 (Any hearing loss), *n* = 436	1.45 (0.97–2.17)	1.40 (0.93–2.11)
	>25 to ≤40 (Mild hearing loss), *n* = 315	1.30 (0.83–2.03)	1.25 (0.79–1.96)
	>40 (Moderate–severe hearing loss), *n* = 121	1.90 (1.06–3.40)	1.87 (1.04–3.36)
Best corrected	≤25 (No hearing loss), *n* = 67	1.57 (0.74–3.31)	1.51 (0.71–3.21)
	>25 (Any hearing loss), *n* = 78	1.84 (0.93–3.65)	1.85 (0.93–3.68)
	>25 to ≤40 (Mild hearing loss), *n* = 55	2.24 (1.06–4.74)	2.19 (1.03–4.67)
	>40 (Moderate–severe hearing loss), *n* = 23	1.11 (0.30–4.07)	1.20 (0.32–4.44)

OR, odds ratio; CI, confidence interval.

[a]Further adjusting for the presence of a walking disability and three or more co-morbidities.

instance, persons with co-existing best-corrected visual impairment and mild hearing loss versus those with no sensory loss at baseline had a 2-fold increased risk of incident falls (i.e. 1 or more falls) 5 years later: multivariable-adjusted OR 2.16 (95% CI 1.04–4.50). However, the association between moderate to severe hearing loss but no best-corrected visual impairment compared with those with no sensory impairments and incidence of any falls (>1) became non-significant: multivariable-adjusted OR 1.18 (95% CI 0.68–2.05). Non-significant associations were observed among those who had co-existing presenting visual impairment and any hearing loss, and incidence of any falls (data not shown).

Discussion

Identifying modifiable risk factors for falls in older adults is of significant public health importance [8]. Hearing aid users as well as those who experienced severe hearing handicap were more likely to report falls over the 5-year period. Older adults with co-existing best-corrected visual impairment and mild hearing loss at baseline had ~2-fold increased risk of experiencing 2 or more falls 5 years later. This association did not persist, however, once we had excluded persons with cognitive impairment.

Our cohort study indicates that severe hearing handicap rather than measured hearing impairment *per se* was a significant and independent predictor of experiencing falls among adults aged 55 and over. In contrast, Lin and Ferrucci [8] and Viljanen *et al.*[5] showed an independent association between hearing loss determined by pure-tone audiometry and prevalence and incidence of falls, respectively. However, a prospective US study of older women reported that objectively measured hearing loss was not a risk factor for falls [12]. Possible reasons for the divergent results reported across studies are variability in the measurement and classification of hearing loss, study design (i.e. some were cross-sectional while others were longitudinal), differences in the age–sex distribution of the cohorts (e.g. some comprised women only), and variability in how falls were assessed [8].

The data from this current study concur with our prior publication showing that HHIE-S scores rather than objectively assessed hearing had a greater adverse impact on many of the SF-36 (health-related quality of life instrument) domains including physical composite score and the 'role limitation due to physical problems', 'general health' and 'bodily pain' [14]. It is unclear as to how the presence of a severe hearing handicap independently increases risk of falling. Self-reported hearing handicap is likely to be the result of interactions between the magnitude of hearing loss and cognitive ability [23], which declines with age [24]. Hearing loss increases the cognitive load needed to listen [25], which is important for walking, navigating through crowds and walking across roads. Therefore, severe hearing handicap is likely to compete for the same processing demands needed for postural control and walking. Physical decline, falling and impaired balance from accompanying decreased vestibular function could be affected more in those with hearing loss and greater cognitive decline [17, 26]. An alternate explanation is that chronic stress (e.g. self-perceptions of social isolation and an inactive social life directly due to a hearing loss) could be severe enough to stimulate autonomic, neuro-endocrine and immunological responses leading to physical disease [27], frailty and/or adversely impacting on the interaction of multiple physiological systems needed to maintain an upright position; hence, increasing the risk of falling in the longer term. Alternatively, people with self-perceived hearing handicap could be less effective at accessing and using health-care services that might improve or protect their physical health [14, 27] or prevent frailty, and this in turn could place them at increased risk of falling. Finally, it could be that severe hearing handicap leads to decreased participation in everyday activities, and this, in turn, could accelerate the disablement process and increase fall risk [5]. We caution, however, that ours could be a chance finding and that other longitudinal studies are needed to further assess the association between self-perceived hearing handicap and the incidence of falls.

A surprising finding was that the use of hearing aids was associated with an increased risk of falling over the 5-year follow-up. This contrasts with the literature which shows that hearing aid use has a beneficial impact on health status including improved mood and reduced depression, better quality of life and longer life expectancy [14, 28–31]. We speculate that hearing aid use is unlikely to be the direct cause of increased falls in the longer term, but rather a marker of more severe hearing handicap or potentially a marker of frailty and ageing. Also, those who feel more handicapped by their hearing loss or are experiencing greater emotional distress as a direct result of their hearing impairment are those who are more likely to wear a hearing aid [15, 32].

The significant association between DSI and increased risk of falling over 5 years concur with previous reports suggesting that the presence of more than one sensory impairment increases morbidity relative to single sensory impairments [33, 34, 35, 36]. Moreover, this finding suggests a potential interactive effect of DSI on risk of falls, that is, the negative effects of vision are multiplied by the effects from hearing loss [37, 38]. However, given that the interaction between best-corrected visual impairment and hearing loss on incidence of falls was statistically non-significant, it suggests that the effects of hearing and vision loss on falling are likely to additive, rather than multiplicative. The complex structure of the sensory input involved in maintaining an upright position and the interaction between vision and auditory systems makes it possible for people with only one sensory impairment to compensate for the lack of information from that channel by using other sensory information available [16]. Therefore, a possible explanation for our observation is that the increased impact of vision impairment on fall risk, when accompanied with a hearing impairment, is due to lack of compensatory information about body posture and the environment from other sensory sources [16]. Alternatively, it is speculated that the presence of DSI could be a marker for frailty (e.g. handgrip strength), illness or possibly accelerated ageing processes [34, 39].

We also need to highlight that the association between DSI and incidence of falls was not present among those without cognitive impairment. Previous studies have suggested that cognitive function is related to future fall risk [21, 22]. Given that older adults with DSI are at increased risk of cognitive decline [40], it is plausible that there is a complex interplay between DSI, cognition and falls. For instance, DSI could contribute to increased inattentiveness in cognitively impaired persons, and that this risk may be superimposed on individuals who are already at a high risk for falls. Hence, cognitive function could at least partly explain the relationship between co-existing vision and hearing loss and future falls in older adults.

As sensory problems are common experiences within older age groups, they are often overlooked or dismissed [33, 38]. Our study could have potential public health implications, as it suggests that identifying and targeting DSI in older adults could be a potentially useful strategy for preventing falls in the longer term. Specifically, regular assessment of the presence of DSI in older persons could lead to earlier detection and facilitation of rehabilitation and therapy that could reduce the negative impacts of DSI [38]. Correction of visual and hearing impairment, including the provision of corrective lenses, assistive devices (e.g. magnifiers, listening devices) and rehabilitative services such as visual, auditory and communication training [34, 41] should be encouraged and/or implemented by clinicians, as it could improve attentional resources and in turn maintain postural control in older adults.

Strengths of our study include its large population-based sample with reasonable follow-up rates and the use of standardised audiometric and vision testing to assess sensory impairments. However, the study had several noteworthy limitations. First, falls were self-reported and could have been subject to recall bias [42]. Second, while we had robust data on a range of confounders, other unmeasured or unknown factors (e.g. lifestyle or societal factors) could have influenced our study findings. Third, we cannot disregard survival bias. Persons who did not attend follow-up visits could have been frailer, have had more co-morbid conditions including sensory impairments and, thus, would have had more falls than persons who did attend, resulting in an under-reporting event rate of falls and potential underestimation of the associations [9]. Finally, the lack of a dose–response relationship between DSI and risk of falls is likely to be due to reduced statistical power, that is, a very small proportion around 1–4% in the BMES had both visual impairment (either best-corrected visual impairment or presenting) and severe hearing loss. Hence, we may not have sufficient power to detect any modest associations with incident falls.

In summary, we show that hearing aid users as well as those who experienced severe hearing handicap were more likely to report two or more falls over the 5-year period. We also found that the presence of DSI independently predicted an increased risk of falls in older adults. However, this association did not persist among those with normal cognitive function. Additional research is needed to establish whether co-existing sensory impairments are a modifiable risk factor for falls that could be amenable to rehabilitative services and/or visual, auditory and communication training strategies.

Key points

- Hearing aid users and those who experienced severe hearing handicap were more likely to report falls over the 5 years.
- Co-existing best-corrected visual impairment and mild hearing loss were associated with increased risk of falls.
- This association did not persist; however, once we had excluded persons with cognitive impairment.

Supplementary data

Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

Conflicts of interest

None declared.

References

Only the most important are listed here and are represented by bold type throughout the text. The full list of references is available as Supplementary data, Appendix S3, available in *Age and Ageing* online.

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