Does Walking Speed Mediate the Association Between Visual Impairment and Self-Report of Mobility Disability? The Salisbury Eye Evaluation Study

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OBJECTIVES: To determine whether performance speeds mediate the association between visual impairment and self-reported mobility disability over an 8-year period.

DESIGN: Longitudinal analysis.

SETTING: Salisbury, Maryland.

PARTICIPANTS: Salisbury Eye Evaluation Study participants aged 65 and older (N = 2,520).

MEASUREMENTS: Visual impairment was defined as best-corrected visual acuity worse than 20/40 in the better-seeing eye or visual field less than 20°. Self-reported mobility disability on three tasks was assessed: walking up stairs, walking down stairs, and walking 150 feet. Performance speed on three similar tasks was measured: walking up steps (steps/s), walking down steps (steps/s), and walking 4 m (m/s).

RESULTS: For each year of observation, the odds of reporting mobility disability was significantly greater for participants who were visually impaired (VI) than for those who were not (NVI) (odds ratio (OR) $_{\text{difficulty walking up steps}}$ = 1.58, 95% confidence interval (CI) = 1.32–1.89; OR $_{\text{difficulty walking down steps}}$ = 1.90, 95% CI = 1.59–2.28; OR $_{\text{difficulty walking 150 feet}}$ = 2.11, 95% CI = 1.77–2.51). Once performance speed on a similar mobility task was included in the models, VI participants were no longer more likely to report mobility disability than those who were NVI (OR $_{\text{difficulty walking up steps}}$ = 0.84, 95% CI = 0.65–1.11; OR $_{\text{difficulty walking down steps}}$ = 0.96, 95% CI = 0.74–1.24; OR $_{\text{difficulty walking 150 feet}}$ = 1.22, 95% CI = 0.98–1.50).

CONCLUSION: Slower performance speed in VI individuals largely accounted for the difference in the odds of reporting mobility disability, suggesting that VI older adults walk slower and are therefore more likely to report mobility disability than those who are NVI. Improving mobility performance in older adults with visual impairment may minimize the perception of mobility disability. **J Am Geriatr Soc 62:1540–1545, 2014.**

Key words: visual impairment; mobility; disability; aging

Visual impairment is the reported cause of disability in 3.9% of women and 2.8% of men aged 40 and older in the United States.[1] Visually impaired (VI) older adults have been shown to have poorer self-rated health status and lower self-rated functioning than their non-visually impaired (NVI) counterparts,[2–6] but lack of mobility may be among the most debilitating consequences of vision loss, because it can lead to social isolation and more-advanced disabilities, such as with activities of daily living (ADLs).[3,7] The literature suggests that VI older adults are more likely to report mobility difficulty[3,7,8] and have slower walking speeds, than their NVI counterparts.[2,4–6]

Conceptual models have been proposed in an effort to clarify the pathway from a health condition to disability.[9–11] The World Health Organization (WHO) model posits that the disability pathway starts with a disease or health condition and that consequent changes in functioning can lead to changes in the perception of functioning.[11] This WHO disability framework has been applied to mobility disability using data from the Women's Health and Aging Study II, showing that nondisabled individuals with slow walking speeds at baseline were more likely to report mobility disability 18 months later than those with moderate or fast walking speeds,[12] suggesting that declines in mobility performance precede the report of mobility task difficulty, or mobility disability, but the pathway from visual impairment to mobility disability has not been examined, and the

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DOI: 10.1111/jgs.12937

0002-8614/14/$15.00

role of mobility performance in this pathway is unknown. This study used longitudinal data from the Salisbury Eye Evaluation Study (SEE) to test the WHO disability framework and the hypothesis that mobility performance mediates the association between visual impairment status and mobility disability.

METHODS

The Johns Hopkins School of Medicine institutional review board approved this research, and informed consent was obtained for all participants according to the Declaration of Helsinki.

Study Population

SEE is a population-based longitudinal study that began in 1993 and included 2,520 residents of Salisbury, Maryland, aged 65 and older. The recruitment and eligibility criteria of SEE have been previously described.[3] Clinic visits occurred at baseline and 2, 6, and 8 years after baseline.

Visual Impairment

Distance visual acuity was measured using an Early Treatment for Diabetic Retinopathy Study chart.[13] Best-corrected visual acuity in the better-seeing eye was used for these analyses.

Visual fields were measured using a Humphrey single-intensity (24 dB) full-field (60°) screen (Humphrey Field Analyzer, Carl Zeiss Meditec, Dublin, CA). This test is scored as the number of points missed (out of 96 possible points) during the examination. The visual fields were separated into three areas: central (56 points), upper peripheral (18 points), and lower peripheral fields (22 points). Monocular visual fields were measured, and binocular visual fields were estimated from the composite of the more sensitive of the visual field locations from each eye.[14] The composite binocular visual field was scored as number of points missed on the visual field examination in each of the three areas measured. The central field measured corresponds to approximately 20° of the visual field.

Visual impairment was defined as best-corrected distance visual acuity worse than 20/40 in the better-seeing eye or missing all of the points in the upper and lower peripheral fields of the visual field test. This visual acuity cut point corresponds to the American Academy of Ophthalmology (AAO) definition of visual impairment = (best-corrected distance visual acuity worse than 20/40),[15] but the AAO does not use visual fields to categorize visual impairment. Therefore, the WHO *International Classification of Diseases, Tenth Revision*, definition of impairment as less than 20° of visual field was also used.[16] Visual impairment was analyzed as a time-varying covariate, allowing individuals to change between NVI and VI at each study visit.

Mobility Disability

The primary outcome of interest was mobility disability, defined as self-reported difficulty with mobility tasks. In SEE, an adaptation of questionnaires developed by Rosow, Breslau, and Nagi[9,17] was used to assess difficulty with mobility. Participants were asked about difficulty walking up 10 steps, walking down 10 steps, and walking 150 feet. The lead-in for each question was, "By yourself, that is without help from another person or special equipment, do you have any difficulty with…?" The responses to this question was a scale of difficulty that included no difficulty, a little difficulty, moderate difficulty, extreme difficulty, and cannot perform activity for health or physical reasons. For each task, responses were collapsed into a binary variable (no difficulty vs any difficulty or unable to complete the mobility task).

Performance Speeds

Stairs were standardized and set at a 32° incline. Time to walk up 7 steps, walk down 7 steps, and walk 4 m was measured in seconds. These values were then used to calculate speed in steps/s or m/s. Speeds were measured at every SEE visit and were included in the models as time-varying covariates.

Other Covariates

In addition to the variables described above, SEE has data on age, sex, and self-designated race (white or black) based on the Medicare files. The baseline values of these covariates were used in the analysis. Previous research has indicated that the risk of visual impairment and disability increases nonlinearly with age.[3] To capture this nonlinear association, age at baseline was categorized as 65 to 69, 70 to 74, 75 to 80, and 80 and older.

All other covariates used in the analyses were time varying. Body mass index (BMI) was measured at each visit and categorized a underweight (<18.5.0 kg/m^2), normal weight (18.5–24.9 kg/m^2), and overweight or obese (≥25.0 kg/m^2). Smoking status was assessed according to self-report (never smoker vs current or former smoker).

Comorbid conditions are known to negatively affect mobility,[18,19] so participants were asked questions about their comorbidities using the lead in "Has a doctor ever told you that you have…?" These conditions were arthritis, hip fracture, back problem, heart attack or myocardial infarction, angina pectoris or chest pain, congestive heart failure, intermittent claudication pain in the legs, high blood pressure, emphysema, asthma after age 50, stroke, Parkinson's disease, cancer or malignancy, and vertigo or Ménière's disease. The number of comorbid conditions was then classified as none, one, two, or three or more conditions.

Because diabetes mellitus can lead to visual impairment and mobility disability, it was examined separately from the comorbidity covariate described above. The presence of diabetes mellitus was recorded if glycosylated hemoglobin values were above 7% or if a doctor had ever told the participant that he or she had diabetes mellitus. The presence of depressive symptoms was assessed using the seven-item depressive symptom subscale of the General Health Questionnaire.[20,21] An individual was categorized as having depressive symptoms if her or she responded yes to one or more of the seven questions about worthlessness, suicidal thoughts, and hopelessness. Cognitive status was

assessed using the Mini-Mental State Examination (MMSE) and categorized as less than 24 versus 24 and greater.[22]

Statistical Analysis

Contingency tables were used to compare the distribution of potential confounders accoridng to visual impairment at baseline. VI and NVI participants were compared using chi-square or *t*-tests. Generalized estimating equation models using an exchangeable correlation matrix were used to generate odds ratios (ORs) and to analyze the longitudinal relationships between visual impairment and mobility outcomes while accounting for the correlation between the repeated measures.[23] Models were also fit using an independent correlation structure, and inferences were similar. Robust variance estimators were used to obtain 95% confidence intervals (CIs) for predictor associations with the self-report of difficulty walking up 10 steps, walking down 10 steps, and walking 150 feet. For time-varying covariates, values concurrent with outcome values were used in the models. Quasilikelihood information criteria values were used to assess model goodness of fit.[24]

The regression models were extended to include performance speeds on the corresponding mobility test. For example, the model in which reported difficulty walking up stairs was extended to include stair-climbing speed. Performance speeds were centered at the baseline population mean and were rescaled by multiplying these speeds by –10 so that the interpretation of these covariates would be the increase in odds of reporting mobility disability per 0.1 steps/s or a 0.1-m/s decrease in speed. The models were again extended to include age, sex, race, smoking status, BMI, MMSE score, number of other health conditions, depressive symptoms, and diabetes mellitus.

Sensitivity analyses were used to determine whether the results were robust to the definition of visual impairment. The primary analyses were rerun after the cut point for visual acuity was shifted from 20/40 to best-corrected distance visual acuity worse than 20/60 in the better-seeing eye. Similar to the definition above, participants missing all of the points in the upper and lower peripheral fields of the visual field test were classified as VI.

The possibility that the results reflected reverse causation was examined by excluding participants who reported mobility disability at baseline to assess how performance speed predicted incident mobility disability. Performance speeds were lagged by one study visit and included in pooled logistic regression models (adjusting for the covariates in the final models described above), with individuals removed from further modeling after they developed disability.

Data were analyzed using Stata 12 (Stata Corp., College Station, TX) and SAS version 9 (SAS Institute Inc., Cary, NC).

RESULTS

Participant Characteristics

At baseline, 169 (7%) participants who were categorized as VI and 2,351 (93%) as NVI. VI participants were significantly older and, after adjustment for age, were more likely to be black, have an MMSE score less than 24, have diabetes mellitus, and report depressive symptoms than NVI participants at baseline (Table 1). Two hundred forty-nine SEE participants (11%) were classified as VI at the 2-year visit, 185 (12%) at the 6-year visit, and 139 (11%) at the 8-year visit.

Mobility disability

In unadjusted models, the odds of reporting difficulty with each mobility task increased per year of observation ($OR_{walking\ up\ stairs}$ = 1.09, 95% CI = 1.07–1.10; $OR_{walking\ down\ stairs}$ = 1.12, 95% CI = 1.10–1.13; $OR_{walking\ 150\ ft}$ = 1.13, 95% CI = 1.11–1.14), and VI participants were more likely to report difficulty than NVI participants ($OR_{walking\ up\ stairs}$ = 1.58, 95% CI = 1.32–1.89; $OR_{walking\ down\ stairs}$ = 1.90, 95% CI = 1.59–2.28; $OR_{walking\ 150\ ft}$ = 2.11, 95% CI = 1.77–2.51) (Table 2, Model 1a). After adding speed on these tasks to the models, the

Table 1. Baseline Characteristics According to Visual Impairment Status: The Salisbury Eye Evaluation Study

Characteristic	Visually Impaired at Baseline, n = 169 (7%)	Not Visually Impaired at Baseline, n = 2,351 (93%)	*P*-Value[a]
Demographic characteristics			
Age at baseline			
65–69	28 (16.6)	752 (32.0)	<.001
70–74	42 (24.9)	793 (33.7)	
75–79	38 (22.5)	516 (22.0)	
≥80	61 (36.1)	290 (12.3)	
Female	103 (61.0)	1,355 (57.6)	.40
White	96 (56.8)	1,758 (74.8)	<.001
Smoking status			
Never	70 (41.4)	927 (39.4)	.77
Current or former	98 (58.0)	1,416 (60.6)	
Body mass index, kg/m^2			
<18.5 (underweight)	7 (4.1)	45 (1.9)	.16
18.5–24.9 (normal)	52 (30.8)	655 (27.9)	
≥25.0 (overweight or obese)	110 (65.1)	1,651 (70.2)	
Mini-Mental State Examination Score			
<24	53 (31.4)	224 (9.5)	<.001
≥24	116 (68.6)	2,127 (90.5)	
Comorbid conditions			
Depressive symptoms	30 (17.8)	206 (8.9)	<.001
Diabetes mellitus	74 (43.8)	702 (29.9)	<.001
Number of other health conditions[b]			
0	21 (12.4)	246 (10.5)	.39
1	37 (21.9)	565 (24.0)	
2	41 (24.3)	679 (28.9)	
≥3	70 (41.4)	861 (36.6)	

[a]Age-adjusted *P*-values.
[b]Not including visual impairment, depressive symptoms, or diabetes mellitus.

associations between visual impairment and task difficulty were attenuated and no longer statistically significant ($OR_{walking\ up\ stairs}$ = 0.84, 95% CI = 0.65–1.11; $OR_{walking\ down\ stairs}$ = 0.96, 95% CI = 0.74–1.24; $OR_{walking\ 150\ ft}$ = 1.22, 95% CI = 0.98–1.50). For every 0.1-steps/s or 0.1-m/s decrease in these speeds, the odds of reporting difficulty increased ($OR_{walking\ up\ stairs}$ = 1.65, 95% CI = 1.59–1.72; $OR_{walking\ down\ stairs}$ = 1.53, 95% CI = 1.46–1.59; $OR_{walking\ 150\ ft}$ = 1.73, 95% CI = 1.67–1.80) (Table 2, Model 1b). After adjusting for all other covariates, these inferences were largely unchanged (Table 2, Model 1c).

Sensitivity Analyses

To determine whether the results were robust to the definition of visual impairment, the definition of visual impairment was shifted to distance visual acuity worse than 20/60. Using this definition, 117 (5%) were classified as VI at baseline, 137 (6%) at the 2-year visit, 105 (7%) at the 6-year visit, and 58 (5%) at the 8-year visit. The final models were rerun using this classification of visual impairment, and it was found that, after including performance speeds in the models, visual impairment was not associated with report of mobility difficulty for any of the outcomes ($OR_{walking\ up\ stairs}$ = 0.90, 95% CI = 0.63–1.28; $OR_{walking\ down\ stairs}$ = 1.02, 95% CI = 0.73–1.44, $OR_{walking\ 150\ ft}$ = 1.31; 95% CI = 1.00–1.72).

Further Mediation Testing

It is also possible that the findings were due to reverse causation, with the perception of mobility difficulty leading to slower performance speeds. To test this, the primary analyses were rerun after individuals with mobility disability at baseline were excluded, and incident mobility disability was examined for each task (Table 3). At baseline, 848 (34%) SEE participants reported difficulty walking up stairs, 548 (22%) reported difficulty walking down stairs, and 374 (15%) reported difficulty walking 150 feet at baseline. After excluding these participants, performance from the prior study visit significantly predicted the incident report of difficulty on all three mobility tasks (Table 3). Similar to the primary results, lagged performance speeds attenuated but did not eliminate the difference between VI and NVI individuals in reporting incident disability.

DISCUSSION

These results support the hypothesis that performance speeds mediate the association between visual impairment status and perceived mobility difficulty. After performance speeds were included in the regression models, the association between visual impairment and report of mobility disability was attenuated and no longer statistically significant. These results were largely unchanged after the addition of demographic and health characteristics to the model and in sensitivity analyses in which the definition of visual impairment was changed. The current authors also found that performance speeds at the prior study visit were significant predictors of incident mobility disability and attenuated the association between visual impairment and incident mobility disability. The results from these additional analyses suggest that it is unlikely that the definition of visual impairment or reverse causation led to the primary findings.

These analyses were used as a test of the conceptual framework, based on the disablement model presented by the WHO, indicating that changes in functioning can lead to changes in the perception of functioning.[11] This model has been applied to mobility outcomes using data from the Women's Health and Aging Study II,[12] although the current authors believe that this study is one of the first

Table 2. Longitudinal Association Between Self-Reported Difficulty and Visual Impairment: The Salisbury Eye Evaluation Study

Covariate	Model 1a[a]	Model 1b[b]	Model 1c[c]
	Odds Ratio (95% Confidence Interval)		
Difficulty walking up stairs			
Years since baseline (per year)	1.09 (1.07–1.10)	1.00 (0.98–1.02)	1.02 (0.99–1.04)
Visually impaired[d]	1.58 (1.32–1.89)	0.84 (0.65–1.11)	0.97 (0.74–1.28)
Stair climbing speed (per 0.1-steps/s decrease)		1.65 (1.59–1.72)	1.61 (1.54–1.69)
Difficulty walking down stairs			
Years since baseline (per year)	1.12 (1.10–1.13)	1.05 (1.03–1.07)	1.07 (1.05–1.10)
Visually impaired[d]	1.90 (1.59–2.28)	0.96 (0.74–1.24)	1.05 (0.80–1.37)
Stair descent speed (per 0.1-steps/s decrease)		1.53 (1.46–1.59)	1.50 (1.42–1.57)
Difficulty walking 150 feet			
Years since baseline (per year)	1.13 (1.11–1.14)	1.06 (1.04–1.08)	1.07 (1.04–1.10)
Visually impaired[d]	2.11 (1.77–2.51)	1.22 (0.98–1.50)	1.17 (0.93–1.46)
4-m speed (per 0.1-steps/s decrease)		1.73 (1.67–1.80)	1.69 (1.62–1.77)

[a] Model included covariates for years since baseline and visual impairment status.

[b] Model included covariates in Model 1a plus speed on mobility task.

[c] Model included covariates in Models 1a and b plus baseline age category (65–69, 70–74, 75–79, ≥80), sex, race (black, white), smoking status (ever, never), body mass index (underweight, normal, overweight or obese), number of health conditions (0, 1, 2, ≥3), depressive symptoms, and diabetes mellitus.

[d] Best-corrected distance visual acuity worse in than 20/40 in the better-seeing eye or binocular visual fields less than 20°.

Table 3. Association Between Incident Self-Reported Mobility Difficulty and Visual Impairment: The Salisbury Eye Evaluation Study

	Incident Report of Difficulty Walking Up Stairs		Incident Report of Difficulty Walking Down Stairs		Incident Report of Difficulty Walking 150 Feet	
	Base Model	Base Model + Lagged Performance Speed	Base Model	Base Model + Lagged Performance Speed	Base Model	Base Model + Lagged Performance Speed
Covariate	Odds Ratio (95% Confidence Interval)					
Visually impaired[a]	1.43 (1.30–1.18)	1.07 (0.74–1.53)	1.78 (1.31–2.41)	1.47 (1.05–2.06)	1.76 (1.33–2.34)	1.40 (1.05–1.88)
Lagged performance speed per 0.1-steps/s or 0.1-m/s decrease[b]		1.31 (1.22–1.40)		1.14 (1.05–1.24)		1.40 (1.31–1.49)

Analyses excluded participants who reported mobility difficulty at baseline.
Models adjusted for baseline age category (65–69, 70–74, 75–79, ≥80), sex, race (black, white), smoking status (ever, never), body mass index (underweight, normal, overweight or obese), number of health conditions category (0, 1, 2, ≥3), depressive symptoms, and diabetes mellitus.
[a]Best-corrected distance visual acuity worse than 20/40 in the better-seeing eye or binocular visual fields less than 20°.
[b]Performance speeds were lagged by one study visit, and individuals were removed from further modeling after they developed disability.

applications of this model to determine a potential pathway from visual impairment to mobility disability. The relationship between performance speed and incident disability that was observed mirrors previous results, adding validity to the findings.[12]

Overall, the results from this study underscore the negative effect of visual impairment on mobility disability and suggest an important intervention point. The findings suggest that VI older adults walk more slowly and, as a result, are more likely to report mobility disability than NVI individuals. Therefore, improvements in mobility performance could result in a reduction of perceived mobility disability in VI older adults. This conclusion may be of significance for aging researchers, because a recent review of the literature found that the effect of mobility interventions is understudied in older populations with visual impairment.[25] This study highlights the need for randomized controlled studies comparing the effectiveness of rehabilitation models that include mobility training for older adults with vision loss.

ACKNOWLEDGMENTS

A portion of this research was submitted as an abstract to the Association of Research in Vision and Ophthalmology meeting, May 4–8, 2014, Orlando, Florida.

This study was supported by Grants AG10184 and T32AG000247 from the National Institute on Aging, National Institutes of Health.

We are grateful to Alison Abraham and Pradeep Ramulu for providing technical input on the analyses used in this manuscript.

Conflict of Interest: There are no conflicts of interest for any of the authors.

Author Contributions: Swenor, Bandeen-Roche: study concept and design; analysis and interpretation of data; drafting and revising article; final approval of the version to be published. Muñoz, West: study concept and design; acquisition of data; analysis and interpretation of data; drafting and revising article; final approval of the version to be published.

Sponsor's Role: The sponsor had no role in any aspect of the analyses or preparation of this manuscript.

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