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

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Abstract

Objectives—To determine if performance speeds mediate the association between visual impairment and self-reported mobility disability over an eight-year period.

Design—Longitudinal analysis

Setting—Salisbury, MD

Participants—2,520 Salisbury Eye Evaluation Study participants, age 65 years or older.

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/second), walking down steps (steps/second), and walking 4 meters (meters/second).

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Results—For each year of observation, the odds of reporting mobility disability was significantly greater for visually impaired than the non-visually impaired ($OR_{\text{difficulty walking up steps}}$ = 1.58, 95% 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, the visually impaired were no longer more likely to report mobility disability than the non-visually impaired ($OR_{\text{difficulty walking up steps}}$ = 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—The difference in the odds of reporting mobility disability by visual impairment status is largely accounted for by slower performance speeds among the visually impaired. This suggests that visually impaired older adults walk slower and are therefore more likely to report mobility disability than the non-visually impaired. Improving mobility performance in older adults with visual impairment may minimize the perception of mobility disability.

Keywords

Visual Impairment; Mobility; Disability; Aging

INTRODUCTION

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

In an effort to clarify the pathway from a health condition to disability, conceptual models have been proposed. [9–11] The World Health Organization (WHO) model posits that the disability pathway starts with a disease or health condition, and consequent changes in actual 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 non-disabled participants 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] This result suggests that declines in mobility performance precede the report of mobility task difficulty, or mobility disability.

However, the pathway from visual impairment to mobility disability has not been examined, and the role of mobility performance in this pathway is unknown. This study aims to use longitudinal data from the Salisbury Eye Evaluation Study (SEE) to test the WHO disability framework and our hypothesis that mobility performance mediates the association between visual impairment status and mobility disability.

METHODS

Institutional Review Board of the Johns Hopkins School of Medicine approved this research, and informed consent was obtained for all participants according to the Declaration of Helsinki.

Study Population

The SEE study is a population-based longitudinal study that began in 1993 and included 2,520 residents of Salisbury, MD ages 65 years and older. The recruitment and eligibility criteria of the SEE study have been previously described. [3] Clinic visits occurred at baseline, as well as two-, six-, and eight-years after baseline.

Visual Impairment

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

Visual fields were measured using a Humphrey single intensity (24dB) full field (60 degrees) 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 exam. The visual fields were separated into three areas: the central (56 points), upper peripheral (18 points), and lower peripheral fields (22 points). Monocular visual fields were measured, and binocular visual fields 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 exam in each of the three areas measured. The central field measured corresponds to approximately 20° of visual field.

Visual impairment was defined as best-corrected distance visual acuity worse than 20/40 in the better-seeing eye and/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] However, the AAO does not use visual fields to categorize visual impairment. Therefore, the WHO International Classification of Disease (ICD-10) definition of impairment as less than 20 degrees 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

Our primary outcome of interest was mobility disability, defined as self-reported difficulty with mobility tasks. In the SEE study, an adaptation of questionnaires developed by Rosow, Breslau and Nagi [9, 17] was used to assess difficulty with mobility. Participants were asked about difficulty with walking up 10 steps, walking down 10 steps, and walking 150 ft. The lead-in for each question asked 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 difficult’, ‘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" or "any difficulty/unable to complete the mobility task").

Performance Speeds

The time to complete the following mobility tests was measured: walking up 7 steps, walking down 7 steps, and walking 4 meters. Stairs were standardized and set at a 32° incline. The time (in seconds) to climb up a set of 7 stairs and the time to descend the same set of steps was recorded. The time to walk 4 meters was also measured (in seconds). These values were then used to calculate speed in steps/second or meters/second. Speeds were measured at every SEE study visit, and were included in our models as time-varying covariates.

Other Covariates

In addition to the variables described above, the SEE study 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 both visual impairment and disability increases non-linearly with age. [3] To capture this non-linear association, age at baseline was categorized as: 65–69, 70 – 74, 75–80, and 80+ years.

All other covariates used in our analyses were time varying. Body mass index (BMI) (kg/m^2) was measured at each visit and categorized into three groups: underweight (<18.5), normal weight (18.5 to <25), and overweight/obese (25+). Smoking status was assessed via self-report (never smoker and current/former smoker).

Comorbid conditions are known to negatively impact mobility. [18, 19] Therefore participants were asked questions about their comorbidities using the lead in "has a doctor ever told you that you have…" These conditions included: arthritis, hip fracture, back problem, heart attack or myocardial infarction, angina 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 Meniere's disease. The number of comorbid conditions was then classified as: 0, 1, 2, or 3+ conditions.

As diabetes can lead to visually impairment as well as mobility disability, this comorbid condition was examined separately from the comorbidity covariate described above. The presence of diabetes was recorded if hemoglobin A1C values were above 7% or if a doctor had ever told them the participant that they had diabetes. 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 they respond 'yes' to one or more of the seven questions about worthlessness, suicidal thoughts, and hopelessness. Cognitive status was assessed using the MMSE, and categorized as ≤ 23 or >23. [22]

Statistical Analysis

Contingency tables were used to compare the distribution of potential confounders by visual impairment status at baseline. The VI were compared to the NVI using chi-square or t-tests. Generalized estimating equation (GEE) models using an exchangeable correlation matrix were used to generate odds ratios (OR) and analyze the longitudinal relationships of visual impairment with mobility outcomes while accounting for the correlation between the repeated measures. [23] We also fit models using an independent correlation structure, and inferences were similar. Robust variance estimators were used to obtain 95% confidence intervals (CI) 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 our models. Quasi-likelihood information criteria (QIC) values were used to assess model goodness of fit. [24]

We extended our regression models to include performance speeds on the corresponding mobility test. For example, the model where reported difficulty walking up stairs was the outcome 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 step/second or 0.1 meter/second decrease in speed. We again extended our models to include age categories, sex, race, smoking status, BMI category, MMSE score, the number of other health conditions, depressive symptoms, and diabetes.

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

We examined the possibility that our results reflected reverse causation, 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 our final models described above), where individuals were removed from further modeling after they developed disability.

Data were analyzed using Stata 12 (Stata Statistical Software: Release 12.1, Stata Corp., College Station, TX) and SAS version 9 (SAS Inc., Cary, NC).

RESULTS

Participant Characteristics

At baseline, 169 (7%) participants who were categorized as VI and 2,351 (93%) were NVI. The VI participants were significantly older, and after adjustment for age were more likely to be black, have an MMSE score less than or equal to 23, and were more likely to have diabetes and report depressive symptoms than the NVI at baseline (Table 1). At the two-year visit, 249 SEE participants (11%) were classified as VI, 185 (12%) at the six-year visit, and 139 (11%) at the eight-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; $OR_{walking\ 150ft}$= 1.13; 95% CI: 1.11–1.14), and the VI were more likely to report difficulty than the NVI ($OR_{walking\ up\ stairs}$ = 1.58; 95% CI: 1.32 – 1.89; $OR_{walking\ down\ stairs}$=1.90; 95% CI: 1.59–2.28; $OR_{walking\ 150ft}$ = 2.11; 95%CI: 1.77–2.51) (Table 2, Models 1a). After adding speed on these tasks to the models, the associations between visual impairment status 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; $OR_{walking\ 150ft}$ =1.22; 95%CI: 0.98–1.50). We found that for every 0.1 steps/second or 0.1 m/second 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; $OR_{walking\ 150ft}$ =1.73, 95% CI: 1.67–1.80) (Table 2, Models 1b). After adjusting for all other covariates, these inferences were largely unchanged (Table 2, Models 1c).

Sensitivity Analyses

To determine if our results were robust to our definition of visual impairment, we shifted our definition of visual impairment to distance visual acuity worse than 20/60. Using this definition, 117 (5%) were classified as visual impaired at baseline, 137 (6%) at the two-year visit, 105 (7%) at the six-year visit, and 58 (5%) at the eight-year visit. We re-ran our final models using this classification of visual impairment, and found that after including performance speeds in the models visual impairment was not associated with the report of mobility difficulty for any of our 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; $OR_{walking\ 150ft}$ =1.31; 95%CI: 1.00–1.72).

Further Mediation Testing

It is also possible that our findings are due to reverse causation, where the perception of mobility difficulty leads to slower performance speeds. To test this, we re-ran our primary analyses after excluding individuals with mobility disability at baseline and examined incident mobility disability for each task (Table 3). At baseline, 848 (34%) SEE participants reported difficulty with walking up stairs, 548 (22%) reported difficulty walking down steps, 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 our primary results, lagged performance speeds attenuated but did not eliminate the difference between the VI and NVI in reporting incident disability.

DISCUSSION

These results support our hypothesis that performance speeds mediate the association between visual impairment status and perceived mobility difficulty. After including performance speeds in our regression models, the association between visual impairment status and the 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 where we changed the definition of visual impairment. We also found that performance speeds at the prior study visit were significant predictors of incident mobility disability, and attenuated the association between visual impairment status and incident mobility disability. The results from these additional analyses suggest that our primary findings are unlikely driven by our definition of visual impairment or by reverse causation.

We used these analyses as a test of our conceptual framework, based on the disablement model presented by the WHO, indicating that changes in actual 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] However, we believe that this study is the one of the first applications of this model to determine a potential pathway from visual impairment to mobility disability. The relationship between performance speed and incident disability that we observed mirrors results from Fried et al., adding validity to our findings. [12]

Overall, the results from this study underscore the negative impact of visual impairment on mobility disability and suggest an important intervention point. Our findings suggest that visually impaired older adults walk slower and as a result are more likely to report mobility disability than the non-visually impaired. Therefore, improvements in mobility performance could result in a reduction of perceived mobility disability among VI older adults. This conclusion may be of significance for aging researchers, as a recent review of the literature found that the impact 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.

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Table 1

Baseline characteristics by visual impairment status: The Salisbury Eye Evaluation Study

	Visually Impaired at Baseline N (%) 169 (7%)	Not Visually Impaired at Baseline N (%) 2,351 (93%)	*P*-value [a]
Demographic Characteristics			
Age at Baseline (years), N (%)			
65 – 69	28 (16.6)	752 (32.0)	
70 – 74	42 (24.9)	793 (33.7)	
75 – 79	38 (22.5)	516 (22.0)	
80+	61 (36.1)	290 (12.3)	**<0.00**
Female, N(%)	103 (61.0)	1,355 (57.6)	0.40
White, N(%)	96 (56.8)	1,758 (74.8)	**<0.00**
Smoking Status, N (%)			
Never	70 (41.4)	927 (39.4)	
Current/Former	98 (58.0)	1,416 (60.6)	0.77
Body Mass Index, N (%)			
<18.5 (Underweight)	7 (4.1)	45 (1.9)	
18.5–24.9 (Normal)	52 (30.8)	655 (27,9)	
25 + (Overweight/Obese)	110 (65.1)	1,651 (70.2)	0.16
Mini-Mental State Exam Score, N (%)			
≤23	53 (31.4)	224 (9.5)	
>23	116 (68.6)	2,127 (90.5)	**<0.00**
Comorbid Conditions			
Depressive Symptoms, N(%)	30 (17.8)	206 (8.9)	**<0.00**
Diabetes, N(%)	74 (43.8)	702 (29.9)	**<0.00**
Number of other Health Conditions, N (%) [b]			
0	21 (12.4)	246 (10.5)	
1	37 (21.9)	565 (24.0)	
2	41 (24.3)	679 (28.9)	
3+	70 (41.4)	861 (36.6)	0.39

[a] Age-adjusted p values

[b] Not including visual impairment, depressive symptoms, and diabetes

Table 2

Longitudinal Association between Self-Reported Difficulty and Visual Impairment: The Salisbury Eye Evaluation Study

	Model 1a[a]		Model 1b[b]		Model 1c[c]	
	Odds Ratio	*95% CI*	*Odds Ratio*	*95% CI*	*Odds Ratio*	*95% CI*
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
Visual Impairment Status [d]						
Not visually impaired	REF	REF	REF	REF	REF	REF
Visually impaired	1.58	1.32 – 1.89	0.84	0.65 – 1.11	0.97	0.74 – 1.28
Stair Climbing Speed (per 0.1 step/s ↓)	--	--	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
Visual Impairment Status [d]						
Not visually impaired	REF	REF	REF	REF	REF	REF
Visually impaired	1.90	1.59 – 2.28	0.96	0.74 – 1.24	1.05	0.80 – 1.37
Stair Descent Speed (per 0.1 step/s ↓)	--	--	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
Visual Impairment Status [d]						
Not visually impaired	REF	REF	REF	REF	REF	REF
Visually impaired	2.11	1.77 – 2.51	1.22	0.98 – 1.50	1.17	0.93 – 1.46
4 Meter Speed (per 0.1 meter/s ↓)	--	--	1.73	1.67 – 1.80	1.69	1.62 – 1.77

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

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

[c] Models include covariates in Models 1a and 1b, plus the following: baseline age category (65–69, 70–74, 75–79, 80+ years), sex, race (black/white), smoking status (ever/never), BMI group (underweight, normal, overweight/obese), # of health conditions category (0, 1, 2, 3+), depressive symptoms, and diabetes.

[d] Visual impairment defined as best-corrected distance visual acuity worse in than 20/40 in the better-seeing eye and/or binocular visual fields less than 20 degrees.

CI = confidence interval

Table 3

Association between Incident Self-Reported Mobility Difficulty and Visual Impairment: The Salisbury Eye Evaluation Study [a]

	Incident report of difficulty walking up stairs				Incident report of difficulty walking down stairs				Incident report of difficulty walking 150 feet			
	Base model [b]		***Base model + Lagged Performance speed*** [b]		***Base model*** [b]		***Base model + Lagged Performance speed*** [b]		***Base model*** [b]		***Base model + Lagged Performance speed*** [b]	
	OR	***95% CI***	***OR***	***95% CI***	***OR*** [a]	***95% CI***	***OR***	***95% CI***	***OR***	***95% CI***	***OR***	***95% CI***
Visual Impairment Status [c]												
Not visually impaired	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF
Visually impaired	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 [d]												
Per 0.1 steps/s or meters/s ↓	----	----	1.31	1.22 – 1.40	----	----	1.14	1.05 – 1.24	----	----	1.40	1.31 – 1.49

[a] Analyses exclude participants who reported mobility difficulty at baseline.

[b] Adjusted for baseline age category (65–69, 70–74, 75–79, 80+ years), sex, race (black/white), smoking status (ever/never), BMI group (underweight, normal, overweight/obese), # of health conditions category (0, 1, 2, 3+), depressive symptoms, and diabetes.

[c] Visual impairment defined as best-corrected distance visual acuity worse in than 20/40 in the better-seeing eye and/or binocular visual fields less than 20 degrees.

[d] Performance speeds were lagged by one study visit, and individuals were removed from further modeling after they developed disability.

OR = odds ratio; CI = confidence interval