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Visual Function, Physical Function, and Activities of Daily Living in Two Aging Communities

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Purpose: We report the distribution of visual acuity impairment (VAI), contrast sensitivity impairment (CSI) and their associations with physical health in an aging population.

Methods: In this cross-sectional analysis, VAI was categorized as mild (20/40–20/60) and moderate or greater (<20/60) in the better eye for distance and near vision. CSI was categorized as moderate (1.04–1.50 logCS) and severe or profound (<1.04 logCS). Physical outcomes included the short physical performance battery (SPPB) scores, self-reported quality of life (QoL) scores, physical limitations, difficulty with activity of daily living (ADL) and instrumental ADL (IADL). The associations between VAI and CSI with physical outcomes were explored overall and by community.

Results: There were 494 Black Jackson and 558 White Washington County participants. The mean age was 80 years, 63% were female, and 15% had $VAI_{\text{distance presenting}}$. Moderate or greater $VAI_{\text{near presenting}}$ was associated with higher prevalence of greater physical limitations (prevalence ratio, 1.25; 95% confidence interval, 1.09–1.44) and IADL difficulties (prevalence ratio, 1.77; 95% confidence interval, 1.32–2.38), but not ADL difficulties. Associations of $VAI_{\text{distance presenting}}$ with physical limitations and lower SPPB scores, and CSI with physical limitations, IADL difficulties, lower QoL, and lower SPPB scores were found. A stratified analysis showed stronger associations in Jackson.

Conclusions: VAI and CSI were associated with poor physical health. These associations should be understood in the context of community differences.

Translational Relevance: Community-based factors may mitigate the impact of vision loss on physical outcomes. Public health endeavors are needed to address VAI and CSI to optimize physical health in the older adults with poor vision.

Introduction

One out of six adults aged 70 years and older experience visual impairment (VI) in the United States.[1] VI typically refers to reduced distance visual acuity (VA).[2] However, visual function encompasses broader aspects such as near VA and contrast sensitivity (CS). Impaired VA and CS have significant consequences, negatively impacting cognitive function, social engagement, physical independence, and quality of life (QoL) in older populations.[3–8]

Physical limitations are increasingly common in older adults compared with previous generations.[9] Among people 80 years and older, 43% have one or more physical limitations, 2.5 times the prevalence seen in persons aged 50 to 59 years.[10] Similarly, reduced health-related QoL and limitations in activity of daily living (ADL) and/or instrumental ADL (IADL) are common in older populations.[11,12] However, few population-based studies have focused on adults aged 70 years and older.[13,14] Understanding the prevalence of multiple aspects of impaired visual function and their associations with physical limitations, daily living dependence, and decreased QoL in people aged 70 years and older is important for healthcare resource allocation, given the increasing life expectancy of our aging population.

However, the impact of VI on physical function may vary, depending on myriad factors. Access to care, social support structure, or living environment may produce differing profiles in burden and affect relationships of vision function. In fact studies indicate people in different communities and minority groups are disparately affected by VI, physical limitations, and decreased QoL.[13,15,16] The differential associations between VI and physical health in communities with different contextual background have yet to be explored.

The Atherosclerosis Risk In Communities (ARIC) study cohort was recruited in 1987–9 with subsequent periodic follow-up visits.[17] The Eye Determinants of Cognition (EyeDOC) study sampled from two of the four ARIC communities, with the aim of understanding the relationships of vision and important aging outcomes. Our study sample represented a bicommunity population aged 70 years and older. Black participants were recruited from Jackson, Mississippi, and White participants were recruited from Washington County, Maryland. We hypothesized that not only VA impairment (VAI) but also CS impairment (CSI) would be associated with lower physical health in the older adult population, and the relationships would differ between the communities.

Methods

Study Setting and Population

Participants were invited to a single EyeDOC study visit if they met a Mini-Mental State Exam score of at least 22 for the Jackson participants or at least 24 for the Washington County participants, thresholds used to exclude participants with probable dementia to enable vision assessment. The EyeDOC visit occurred from June 2017 to May 2019 and was nested between the ARIC sixth and seventh visits when possible. The ARIC and EyeDOC study protocols adhered to the tenets of Helsinki and were approved by the Institutional Review Board at Johns Hopkins University and the University of Mississippi. Written informed consent was obtained from all participants. This cross-sectional analysis used physical function, self-reported physical limitations, difficulties with ADL or IADL, and physical QoL data from the sixth ARIC visit and vision data from the EyeDOC visit.

Visual Function

Participants completed a series of vision assessments during the EyeDOC visit, including distance presenting VA ($VA_{distance\ presenting}$), distance corrected VA ($VA_{distance\ corrected}$), near presenting VA ($VA_{near\ presenting}$), and CS. $VA_{distance\ presenting}$ was measured in the right eye and left eye separately with the participant's habitual correction worn while reading letters from a retro-illuminated Early Treatment Diabetic Retinopathy Study chart (Precision Vision, La Salle, IL). Each participant was asked to start reading at the top line (corresponding with a VA of 20/200) and the total number of letters correctly read was recorded. $VA_{near\ presenting}$ was assessed binocularly using sentences from the MNRead charts (Precision Vision) following standard procedures.[18] Participants were instructed to read the test sentences aloud as quickly and accurately as possible, with the MNRead charts placed at a viewing distance of 40 cm. Reading aids of +1.00 diopters (D) to +3.00 D with 0.50-D increments were provided if needed. All participants underwent refraction using an autorefractor (Nidek ARK 560A, Marco Technologies, Somerset, NJ [Washington County]; Topcon KR-8000, Topcon, Japan [Jackson]), which yielded $VA_{distance\ corrected}$, a measure of VA optimally corrected for refractive error. Assessment of CS was performed using MARS letter CS test (The Mars Perceptrix Corporation, Chappaqua, NY). The right eye and the left eye were tested separately at 40 cm with habitual corrections worn. Numbers of letters correctly identified were documented. The better eye for each aspect of visual function was used in analysis, because the better eye function has been determined to be most influential on physical function and QoL.[19]

Retinal Pathology Assessment

Retinal pathologies were determined based on either retinal image findings or self-report. Retinal imaging centered at the macular and optic nerve head regions was captured in both eyes in a random 10% study participant sample and in one eye in the remaining 90% study participants after dilation using optical coherence tomography scans (Avanti, Optovue Inc., Fremont, CA) and fundus photography (Nidek AFC-330, Nidek Inc., Fremont, CA). One ophthalmologist (X.G.) graded fundus photographs as unremarkable and possible pathology. A senior ophthalmologist (P.R.) graded retinal lesions including retinopathy (as determined by any of the following findings: nonproliferative retinopathy, proliferative retinopathy, clinically significant macular edema); glaucoma;

age-related macular degeneration; and other pathology lesions. Self-reported eye conditions including cataract and surgical treatment, glaucoma, diabetic retinopathy, age-related macular degeneration, and retinal vascular occlusion were assessed using an ocular history questionnaire. Participants also reported whether they currently had an eye care provider.

Physical Function, ADL, IADL, and QoL

Physical health outcomes included physical function assessed using the short physical performance battery (SPPB), self-reported physical ability, and physical QoL. SPPB scores (range, 0–12) were derived from testing of repeated chair stands, balance tests, and a gait speed test.

Self-reported physical ability items belonging to themes of physical limitations and difficulty with ADL and IADL were assessed using standard questionnaires defining level of difficulty (no, a little, much, unable to do, unknown) with various tasks. Physical limitations items included walking for one-quarter of a mile; walking up to 10 steps without resting; stooping, crouching, or kneeling; lifting or carrying something as heavy as 10 pounds; and standing up from an armless chair. ADL items included walking from one room to another on the same level, getting in or out of bed, eating or drinking, and dressing oneself. IADL items included doing chores around the house, preparing one's own meal, and managing one's money. Physical limitations, difficulties with ADL, and difficulties with IADL were categorized as no difficulty (no difficulty on any item), mild difficulty (a little difficulty on any item, but no much difficulty or unable to do any item), or severe difficulty (much difficulty or unable to do any item). Response was set to missing when participants answered unknown for all items.[20]

The physical QoL scores (range, 0–100) were derived from a modified version of the Medical Outcomes Study 12-Item Short Form, where 100 indicates the best possible score.

Covariates

Age in years was calculated at the time of the EyeDOC visit. Median time between the EyeDOC visit and the sixth ARIC visit was 461 days (range, 6–934 days). Self-reported sex, race (Black or White), and education were derived from the baseline ARIC visit. Education was reported as the highest grade or years of school completed and categorized as less than high school, high school or equivalent, or more than high school. Household income, medical history, and lifestyle information was obtained from the sixth ARIC visit (2016–2018) or the seventh visit (2019–2020) when data were unavailable for the sixth visit. Household income was categorized as less than \$35,000/year or \$35,000/year or more. Body mass index was calculated as weight (km) divided by square of height (m). Hypertension was defined as a systolic blood pressure of greater than 140 mm Hg, a diastolic blood pressure of greater than 90 mm Hg or the use of antihypertensive medication. Diabetes was defined as present if the fasting glucose was 126 mg/dL or higher or the nonfasting glucose was 200 mg/dL or higher, or if using medication for diabetes or self-report diagnosis of diabetes. Alcohol use or cigarette smoking were categorized into current or nondrinker/nonsmoker.

Statistical Analysis

Participants with missing visual function or physical health measures were excluded ($n = 20$). Descriptive statistics on demographics and medical history were presented and compared between the communities using the Student t test for normally distributed continuous variables and the χ^2 test for categorical variables. Using the World Health Organization definitions,[21] VAI was categorized as no (20/40 and better), mild (worse than 20/40 and better or equal to 20/60), and moderate or greater (worse than 20/60). $\text{VAI}_{\text{distance corrected}}$ categories were combined into mild or greater (worse than 20/40) for the regression analysis owing to the low participant counts in the moderate or greater category. CSI was categorized as no ($\geq$1.50 logCS), moderate ($\geq$1.04, $<$1.50 logCS), and severe or profound ($<$1.04 logCS). Maximum reading speed and critical print size as functions of reading ability were computed based on reading speed and errors made per sentence read on the MNRead chart.[18,22] Distributions of VAI and CSI in participants younger than and at least 80 years of age were examined by community. Physical health outcomes included continuous measures of SPPB and QoL scores and categorical measures of self-reported physical limitations and ADL and IADL difficulties. We hypothesized each physical health outcome to be associated with VAI or CSI. Univariate proportions of participants with self-reported mild and severe degree of physical limitations, and ADL and IADL difficulties were compared across levels of VAI and CSI using graphical analysis and the one-way analysis of variance test. The associations between each physical health outcome with VAI and CSI categories were assessed using linear regression models (for physical QoL and SPPB scores) or Poisson regression models with robust variance (for severity of physical limitation, difficulty with ADL and

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IADL), adjusting for age, community/race, sex, drinking and smoking status, body mass index, diabetes, and hypertension in the overall sample as well as stratified by the two respective communities. Interaction terms between community and VAI or CSI categories were included in models for each outcome to explore community differences in associations. Regression coefficient and prevalence ratio (PR) estimates along with their 95% confidence interval (CI) were reported. A P value of less than 0.05 was considered as statistically significant based on two-sided tests.

All analyses were performed using STATA 15 (Stata Corp., College Station, TX).

Results

We included a total of 1053 participants (494 [47%] from Jackson and 559 [53%] from Washington County) in the analysis; the mean participant age was 80 years. Participants from Jackson tended to be younger than those from Washington County and more likely to have hypertension. They were less likely to drink, but more likely to smoke. Income tended to be lower in Jackson and educational attainment was higher (Table 1).

VAI and CSI

$VAI_{distance\ presenting}$ was present in 15% of the study population with no statistically significant differences between the two communities. Compared with participants in Washington County, those in Jackson had less $VAI_{distance\ corrected}$ (2.6% vs. 5.6%; $P = 0.002$) and $VAI_{near\ presenting}$ (19% vs. 38%; $P < 0.001$), less CSI (69% vs. 80%; $P < 0.001$), and sharper critical print size (median: 0.30 logarithm of the minimum angle of resolution (logMAR) vs. 0.40 logMAR; $P < 0.001$) but slower reading speed (median, 129 words per minute vs. 171 words per minute; $P < 0.001$) (Table 2). In the full cohort, most distance presenting (69%) and near presenting (70%) VAI was mild. With correction, Jackson participants gained more VA than Washington County (median of 5 Early Treatment Diabetic Retinopathy Study letters vs. 4 Early Treatment Diabetic Retinopathy Study letters, respectively;

Table 1. Demographics Characteristics and Medical History of the Study Population

	Total ($N = 1053$)	Jackson, MS ($n = 494$)	Washington County, MD ($n = 559$)
Age (years),* mean (SD)	80 (4)	80 (4)	81 (4)
Age groups,* % (*n*)			
72 to <80 years	54 (573)	60 (297)	49 (276)
≥80 to 95 years	46 (480)	40 (197)	51 (283)
Female,* % (*n*)	63 (667)	72 (354)	56 (313)
Household income,* % (*n*)			
<$35,000/year	51 (504)	61 (279)	43 (225)
≥$35,000/year	49 (478)	39 (177)	57 (301)
Education,* % (*n*)			
<High school	17 (180)	18 (89)	16 (91)
High school or equivalent	40 (424)	30 (146)	50 (278)
>High school	43 (448)	52 (258)	34 (190)
BMI (kg/m^2),* mean (SD)	29.6 (5.7)	30.2 (5.9)	29.0 (5.4)
Current smoker,* % (*n*)	8.9 (94)	13 (64)	5.4 (30)
Current drinker,* % (*n*)	39 (407)	27 (132)	49 (275)
Diabetes, % (*n*)	39 (407)	42 (204)	37 (203)
Hypertension,* % (*n*)	83 (871)	89 (441)	77 (430)

SD, standard deviation; BMI, body mass index.

There were 38 Jackson participants (7.7%) and 33 Washington County participants (5.9%) missing household income information; 1 Jackson participant (0.2%) missing education information; 3 Jackson participants (0.6%) and 4 Washington County participants (0.7%) missing BMI data; 2 Jackson participants (0.4%) missing current drinking data; 9 Jackson participants (1.8%) and 3 Washing County participants (0.5%) missing diabetes data; and 2 Washing County participants (0.4%) missing hypertension data. Percentage shown in the table were calculated after excluding the participants with missing data for each given variable.

*Statistical significance at $P < 0.05$ level between the 2 communities.

Table 2. Visual Function, Ocular Characteristics, and Physical Health by Community

	Total ($N = 1053$)	Jackson, MS ($n = 494$)	Washington County, MD ($n = 559$)
VAI,* % (n)			
Distance presenting VAI			
Mild ($VA_{distance\ presenting}$ <20/40, ≥20/60)	10 (108)	10 (51)	10 (57)
Moderate or greater ($VA_{distance\ presenting}$ <20/60)	4.6 (48)	3.9 (19)	5.2 (29)
Distance-corrected VAI			
Mild ($VA_{distance\ corrected}$ <20/40, ≥20/60)	3.0 (32)	1.8 (9)	4.1 (23)
Moderate or greater ($VA_{distance\ corrected}$ <20/60)	1.1 (12)	0.8 (4)	1.4 (8)
Near presenting VAI‖			
Mild ($VA_{near\ presenting}$ <20/40, ≥20/60)	20 (208)	8.9 (42)	30 (166)
Moderate or greater ($VA_{near\ presenting}$ <20/60)	8.8 (90)	9.8 (46)	7.9 (44)
CSI,†,‖ % (n)			
Moderate (logCS <1.50, ≥1.04)	73 (750)	67 (314)	78 (436)
Severe or profound (logCS <1.04)	2.6 (27)	3.0 (14)	2.3 (13)
Maximum reading speed (wpm),‖ median (25th percentile, 75th percentile)	151 (124, 179)	129 (110, 151)	171 (145, 189)
Critical print size (logMAR),‖ median (25th percentile, 75th percentile)	0.40 (0.30, 0.60)	0.30 (0.20, 0.50)	0.40 (0.30, 0.60)
Has an eye care provider,‖ % (n)	78 (818)	69 (340)	86 (478)
Self-reported cataract surgery,‖ % (n)	56 (577)	48 (234)	62 (343)
Retinal pathology,‡ % (n)			
Age-related macular degeneration‖	12 (130)	3.6 (18)	20 (112)
Retinopathy§,‖	9.9 (104)	7.5 (37)	12 (67)
Glaucoma‖	15 (154)	19 (94)	11 (60)
Any retinal pathology§,‖	23 (241)	18 (87)	28 (154)
SPPB scores,‖ mean (SD)	8.3 (2.8)	7.6 (3.1)	8.9 (2.4)
Physical limitations, % (n)			
Mild	39 (383)	40 (176)	38 (207)
Severe	36 (359)	36 (160)	36 (199)
Difficulty with ADL, % (n)			
Mild	17 (168)	18 (81)	16 (87)
Severe	4.1 (41)	5.0 (44)	3.5 (19)
Difficulty with IADL, % (n)			
Mild	23 (232)	23 (101)	24 (131)
Severe	7.9 (78)	11 (47)	5.7 (31)
Physical QoL scores,‖ mean (SD)	44 (10)	43 (10)	46 (10)

wpm, words per minute; SD, standard deviation.

Near VA data missing in 25 participants (2.4%) (24 Jackson and 1 Washington County). Self-reported physical limitation data missing in 62 participants (5.9%) (50 Jackson and 12 Washington County); difficulty with ADL data missing in 62 participants (5.9%) (50 Jackson and 12 Washington County); difficulty with IADL data missing in 63 participants (6.0%) (51 Jackson and 12 Washington County).

*VAI defined as a VA of worse than 20/40 (0.3 logMAR) in the better eye.

†CSI defined as CS worse than 1.50 logCS in the better eye.

‡Retinal pathology in at least one eye determined based on self-reported history or retinal photo grading.

§Retinopathy was determined by any of the following findings: nonproliferative retinopathy, proliferative retinopathy, and clinically significant macular edema. Any retinal pathology included age-related macular degeneration, retinopathy, glaucoma, vascular occlusion, retinal atrophy, or other remarkable retinal pathology identified from retinal photos.

The χ^2 test used for comparisons of distributions of visual function impairment, has an eye care provider, had cataract surgery, presence of retinopathy; Wilcoxon rank-sum test used for comparisons of visual function between the 2 communities.

‖Statistically significant differences between the 2 communities at the $P < 0.05$ level.

$P = 0.002$). There was a modest correlation between $VA_{near\ presenting}$ and $VA_{distance\ presenting}$ (Pearson $r = 0.36$). Community differences in VAI severity distributions are shown in Figure 1 by age strata. Lower prevalence of overall near VAI (both $P_{<80years}$ and $P_{\geq 80years}$ < 0.001) and CSI ($P_{<80years} = 0.005$; $P_{\geq 80years} = 0.015$) were seen in Jackson versus Washington County across age strata.

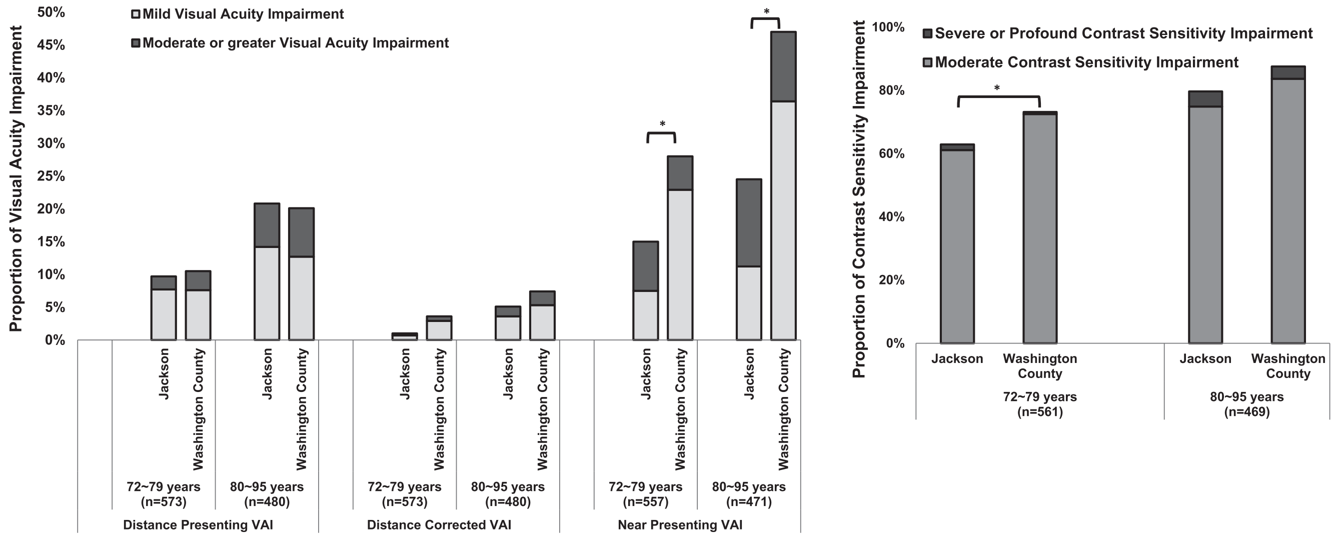

Figure 1. Proportions of participants with different severity of distance presenting, distance corrected, or near presenting VAI, and different severity of CSI by age (72–79 years and 80–95 years) and community (Jackson and Washington County) strata. * Statistical significance at $P < 0.05$ level for differences between the two communities.

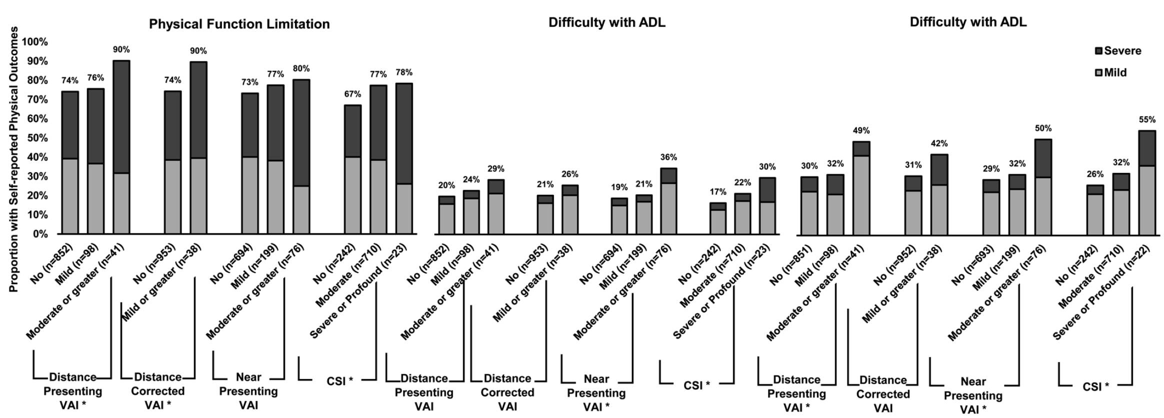

Figure 2. Proportions of participants with self-reported mild and severe physical limitations, difficulty with ADL or IADL by VAI or CSI categories. * Statistical significance at $P < 0.05$ level for trend analysis: trend analysis was performed for any physical limitations or difficulty with ADL, IADL (combination of mild and severe limitations or difficulties). Sample sizes differed by VAI, CSI, and physical outcome categories because of missing physical outcome data in some participants.

Eye Care Access and Retinal Pathology

Jackson participants were less likely to report a history of cataract surgery (48% vs. 62%; $P < 0.001$) or to have an eye care provider (69% vs. 86%; $P < 0.001$) than those from Washington County (Table 2). Overall, 23% of the study population had retinal pathology in at least one eye. Age-related macular degeneration (3.6% vs. 20%; $P < 0.001$) and retinopathy (7.5% vs. 12%; $P = 0.017$) were less prevalent in Jackson than in Washington County, and glaucoma was more prevalent (19% vs. 11%; $P < 0.001$) (Table 2).

Associations of Vision With Physical Abilities

The proportions of participants reported having any level of physical limitations (76% vs. 74%) or difficulties with ADL (23% vs. 19%) or IADL (33% vs. 30%) did not differ significantly between the two communities. However, Jackson participants had higher prevalence of severe difficulty with IADL (Table 2). Unadjusted associations of self-reported mild and severe degree of physical difficulties with VAI and CSI categories are shown in Figure 2. Even in participants with no VAI or CSI, proportions of physical limitations were high. An increasing trend was observed in proportions of any ADL and IADL difficulties with increasing severity of $VAI_{near\ presenting}$ categories using trend analysis ($P_{trend\text{-}ADL} = 0.004$; $P_{trend\text{-}IADL} < 0.001$), similar to the trend with increasing severity of CSI categories ($P_{trend\text{-}ADL} = 0.048$; $P_{trend\text{-}IADL} = 0.010$). Note that possible confounders including age were not adjusted in the trend analysis.

In the overall adjusted regression models (Table 3), those with moderate or greater $VAI_{distance\ presenting}$ (PR, 1.22; 95% CI, 1.07–1.20), or moderate or greater $VAI_{near\ presenting}$ (PR, 1.25; 95% CI, 1.09–1.44), or moderate CSI (PR, 1.19; 95% CI, 1.06–1.33) were more likely to report more severe physical limitations than their counterparts with no $VAI_{distance\ presenting}$, no $VAI_{near\ presenting}$, or no CSI. No significant associations were found between ADL difficulties with VAI or CSI. Those with moderate or greater $VAI_{near\ presenting}$ (PR, 1.77; 95% CI, 1.32–2.38) and those with severe or profound CSI (PR, 1.83; 95% CI, 1.02–3.30) were more likely to experience greater level of IADL difficulties. Specifically, moderate or greater $VAI_{distance\ presenting}$ and moderate or greater CSI were associated with greater difficulty in walking up 10 steps without resting. Participants with mild or greater $VAI_{distance\ corrected}$ or moderate or greater $VAI_{near\ presenting}$ reported greater difficulty with preparing their meals (Supplementary Table S1).

No significant interactions between VAI or CSI and community were found in associations with any of the outcomes. However, nearly all of the effect estimates indicated stronger associations in Jackson than in Washington County in the stratified analysis, with few significant associations in Washington County (Table 3). In the sensitivity analyses where VA and CS were assessed continuously, participants with a decreased $VA_{distance\ corrected}$ were more likely to experience physical limitation; those with a decreased logMAR $VA_{near\ presenting}$ were more likely to report difficulty with IADL.

Associations of Vision With SPPB and Physical QoL

Jackson participants had lower SPPB scores ($P < 0.001$) and lower self-reported physical QoL scores ($P < 0.001$, Table 2). There was a decreasing trend of average SPPB ($P_{trend} < 0.01$) and physical QoL ($P_{trend} = 0.04$) scores with worse $VAI_{distance\ presenting}$ categories. Similarly, lower SPPB and physical QoL scores were observed with worse $VAI_{near\ presenting}$ and CSI categories.

In the overall adjusted regression models, worse SPPB scores were seen in participants with moderate or greater $VAI_{distance\ presenting}$ or $VAI_{near\ presenting}$, or those with CSI. Lower physical QoL scores were seen in those with CSI (Table 3). Significant interactions between VAI categories and community were observed in models assessing the associations of $VAI_{near\ presenting}$ with SPPB scores, and the associations of CSI with SPPB or physical QoL scores. In the stratified models, Jackson participants with moderate or greater $VAI_{distance\ presenting}$ or $VAI_{near\ presenting}$, or with severe or profound CSI had worse SPPB and physical QoL scores (all $P < 0.001$), but these associations were not observed in the Washington County population (Table 3). No association was identified between $VAI_{distance\ corrected}$ and SPPB or physical QoL scores (Supplementary Table S2). When VA and CS were assessed as continuous variables, the associations between declined vision function and poorer SPPB and physical QoL scores remained largely unchanged.

After excluding participants with self-reported or fundus photography identified retinal pathology ($n = 241$), the associations between VAI and CSI categories with physical outcomes remained largely unchanged. However, no associations were found between moderate or greater $VAI_{distance\ presenting}$ and greater self-reported functional limitations in the overall sample. In the overall models, further adjustment for current eye care access did not change the associations between VAI and CSI categories with physical health, though participants with current eye care access were less likely to report having ADL difficulties in all VAI or CSI models.

Discussion

We found a high prevalence of VAI and CSI in this cohort of adults 70 years and older from two racially and contextually distinctive communities of Jackson, Mississippi, and Washington County, Maryland. There was a moderate correlation between presenting VA at distance and near, suggesting that correcting near vision provides an opportunity for improving vision. As hypothesized, VAI and CSI were substantially associated with self-reported physical limitations, IADL difficulties, and poorer QoL overall after adjusting for covariates including age. The associations were stronger in Jackson than Washington County, suggesting that the Washington County participants may be more resilient in coping with impaired visual function. Additionally, Jackson participants gained more VA improvement than Washington County after correcting refractive errors.

Table 3. Associations of VAI, CSI With Physical Health Outcomes in the Overall Population and by Community

	Physical Limitations PR (95% CI)	Difficulty With ADL PR (95% CI)	Difficulty With IADL PR (95% CI)	Physical QoL Scores Coefficient (95% CI)	SPPB Scores Coefficient (95% CI)
Distance Presenting VAI (REF: No $VAI_{distance\ presenting}$)					
Overall					
Mild VAI	1.00 (0.87 to 1.14)	1.04 (0.71 to 1.54)	1.05 (0.76 to 1.47)	−0.85 (−2.83 to 1.13)	−0.51 (−1.02 to 0.002)
Moderate or greater VAI	**1.22*** **(1.07 to 1.20)**	1.09 (0.64 to 1.84)	1.26 (0.84 to 1.89)	−2.46 (−5.33 to 0.40)	**−0.88*** **(−1.64 to −0.12)**
Jackson					
Mild VAI	0.88 (0.69 to 1.14)	0.84 (0.45 to 1.56)	0.77 (0.44 to 1.33)	−0.57 (−3.52 to 2.38)	−0.80 (1.67 to 0.06)
Moderate or greater VAI	**1.37*** **(1.09 to 1.75)**	0.59 (0.24 to 1.48)	1.19 (0.55 to 2.59)	**−5.48*** **(10.02 to −0.94)**	**−1.69*** **(−3.08 to −0.30)**
Washington County					
Mild VAI	1.07 (0.92 to 1.25)	1.28 (0.77 to 2.14)	1.36 (0.90 to 2.06)	−1.32 (−4.01 to 1.37)	−0.40 (−1.01 to 0.21)
Moderate or greater VAI	**1.18*** **(1.01 to 1.39)**	1.64 (0.92 to 2.94)	1.38 (0.87 to 2.20)	−1.26 (−5.02 to 2.51)	−0.66 (−1.53 to 0.22)
Near presenting VAI (REF: No $VAI_{near\ presenting}$)					
Overall					
Mild VAI	1.08 (0.97 to 1.20)	0.99 (0.70 to 1.41)	1.11 (0.85 to 1.45)	−0.43 (−1.99 to 1.12)	−0.08 (−0.47 to 0.31)
Moderate or greater VAI	**1.25*** **(1.09 to 1.44)**	1.36 (0.94 to 1.94)	**1.77*** **(1.32 to 2.38)**	−1.81 (−4.06 to 0.43)	**−0.90*** **(−1.47 to −0.33)**
Jackson					
Mild VAI	0.98 (0.78 to 1.22)	1.02 (0.56 to 1.86)	1.06 (0.65 to 1.73)	0.98 (−2.04 to 4.00)	**1.16*** **(0.31 to 2.02)**
Moderate or greater VAI	**1.26*** **(1.03 to 1.54)**	1.27 (0.79 to 2.02)	**1.93*** **(1.33 to 2.81)**	**−3.45*** **(−6.61 to −0.28)**	**−1.67*** **(−2.56 to −0.77)**
Washington County					
Mild VAI	1.11 (0.98 to 1.25)	0.99 (0.64 to 1.55)	1.13 (0.81 to 1.56)	−0.91 (−2.75 to 0.93)	**−0.46*** **(−0.88 to −0.04)**
Moderate or greater VAI	**1.27*** **(1.04 to 1.54)**	1.56 (0.92 to 2.62)	**1.74*** **(1.12 to 2.71)**	−0.62 (−3.79 to 2.54)	−0.36 (−1.08 to 0.37)
CSI (REF: No CSI)					
Overall					
Moderate CSI	**1.19*** **(1.06 to 1.33)**	1.11 (0.79 to 1.54)	1.27 (0.97 to 1.65)	**−1.44*** **(−2.88 to −0.004)**	**−0.59*** **(−0.95 to −0.23)**
Severe or profound CSI	1.19 (0.92 to 1.51)	1.25 (0.57 to 2.73)	**1.83*** **(1.02 to 3.30)**	**−4.42*** **(−8.34 to −0.49)**	**−1.09*** **(−2.13 to −0.06)**
Jackson					
Moderate CSI	**1.17*** **(1.00 to 1.35)**	1.12 (0.72 to 1.73)	1.41 (0.98 to 2.03)	−1.62 (−3.57 to 0.33)	**−0.72*** **(−1.27 to −0.17)**
Severe or profound CSI	**1.43*** **(1.13 to 1.81)**	1.02 (0.32 to 3.19)	2.11 (0.97 to 4.57)	**−11.40*** **(−16.68 to −6.13)**	**−2.80*** **(−4.46 to −1.13)**
Washington County					
Moderate CSI	**1.22*** **(1.03 to 1.44)**	1.12 (0.67 to 1.85)	1.11 (0.76 to 1.64)	−1.25 (−3.36 to 0.85)	−0.41 (−0.88 to 0.07)
Severe or profound CSI	0.99 (0.65 to 1.53)	1.48 (0.49 to 4.45)	1.50 (0.60 to 3.75)	2.73 (−3.05 to 8.50)	0.31 (−0.99 to 1.61)

No VAI: VA ≥ 20/40; mild VAI: VA ≥20/60, <20/40; moderate or greater VAI: VA <20/60. No CSI: ≥1.50 logCS; moderate CSI: ≥1.04, <1.50 logCS; severe or profound CSI: <1.04 logCS.

Linear regression models were used to examine the associations between VAI and CSI categories with SPPB score and QoL physical health score outcomes; Poisson regression models with robust variance models were used to examine the associations between VAI and CSI categories with self-reported physical functional limitations, difficulties with ADL or IADL outcomes.

Overall models adjusted for age, community, race, sex, current drinking and smoking status, body mass index, diabetes, and hypertension.

Stratified models adjusted for age, sex, current drinking and smoking status, body mass index, diabetes, and hypertension.

*Bold values indicate statistical significance at the $P < 0.05$ level.

The current study found that 15% Washington and 14% Jackson of participants had distance presenting VAI. The comparable numbers from the Salisbury Eye Evaluation (SEE) study in people older than 80 years were 8% in Whites and 11% in Blacks.[13] This finding could suggest an increasing prevalence of VAI over time, because the SEE study was conducted from 1993 to 1995. Similarly, our reported 29% prevalence of near VAI was higher than a previous analysis that reported 10% of adults 60 years and older had presenting near VAI using the National Health and Nutrition Examination Survey data.[23] However, the current sample was substantially older and prevalence of VAI increases drastically with age.[24] We also found a higher prevalence of CSI than previous studies that used the Pelli-Robson instead of MARS CS charts.[25,26] Given the excellent agreement between these tests,[27] the CSI prevalence differences may largely be explained by the population differences.

Visual Function With Physical Function and QoL

Similar to previous studies, the current analysis showed that more severe VAI and CSI are associated with lower SPPB scores and poorer physical QoL in the full cohort.[28,29] Interestingly, evidence is inconclusive regarding how vision is associated with different aspects of physical function. Sorbello et al.[30] identified worse distance VA to be associated with poor balance and step length, but not overall SPPB scores in adults 50 years and older. Another study found that CSI, defined as a 1.25 logCS or less, was associated with failed walking, chair stand, and balance tests; a lack of association was observed between VA and balance.[31] In our analysis, moderate or greater distance or near presenting VAI and moderate or greater CSI were independently associated with lower SPPB scores. Using the Short Form-12 health survey similar to our assessment, Varma et al.[32] found a moderate effect of bilateral VAI on the physical QoL in adult Latinos 40 years and older. In the current analysis, moderate or greater CSI was associated with a lower physical QoL, reflecting poorer general physical health perceptions among those with contrast deficits. The lack of associations between distance-corrected VAI and SPPB or physical QoL scores could indicate that the relationship between VAI and physical function is most notable among those with vision deficit owing to an uncorrected refractive error. This finding suggests an avenue for improving physical function. However, this finding should be interpreted in the context that the proportion of participants with distance corrected VAI in this study sample was extremely low.

Visual Function and Physical Limitations, ADL, IADL

Despite the abundant literature on associations between distance VI and physical abilities,[28,33] few studies have evaluated the relationships between near VAI and physical outcomes. Klein et al.[8] did not find associations between near VA and use of walking aids or change in time to walk a 10-foot course 5 years later in the Beaver Dam Eye Study. Pérés et al.[34] found no associations between near vision and mobility in a French population. However, at least moderate near presenting VAI was associated with greater level of physical limitations in our overall populations, especially with items of stooping, crouching or kneeling, and lifting or carrying heavy items.

People older than 70 years with VI were at least three times as likely to report difficulty with walking and getting outside, managing medications, and preparing meals.[35] Although both distance and near VI were associated with ADL and IADL limitations,[36] these tasks require different skills, with IADLs requiring overall better visual abilities.[5,37] We found that moderate or greater near presenting VAI were associated with greater IADL difficulties, but not ADL difficulties. These findings again highlight the importance of near vision in daily living functionality for older adults.

We found that people with CSI were at higher risk of experiencing greater physical limitations, but not ADL. Severe or profound CSI was associated with greater IADL difficulties in the overall sample, but the association was not retained in the stratified analysis by community. The finding disagreed with previous reports that showed impaired CS to be significantly associated with ADL disabilities.[38,39] One possible explanation is that functional outcomes such as driving at night and face recognition were not included in the current ADL and IADL items; therefore, we may not have captured the tasks that require the most intensive contrast abilities. Additionally, the low prevalence of severe or profound CSI may explain the lack of associations observed between this category and functional outcomes.

Differences Between Communities: How Much Does Context Matter

A lower prevalence of distance-corrected VAI, near presenting VAI, and CSI were seen in the Jackson population. These findings were in contrast with studies that showed VAI being more prevalent in Blacks than Whites,[40] but may speak to the importance of community contextual differences in exposures and access to vision care. Consistent with the current understanding of racial and communal differences in ocular conditions,[41–43] we found a higher prevalence of glaucoma in Jackson; age-related macular degeneration more prevalent in Washington County. Similar to the greater proportions of access to eye service observed with White Medicare beneficiaries[44] and White working age adults with diabetes,[45] Washington County participants were more likely to have an eye care provider. This factor may result in greater awareness and explain the greater proportion of self-reported cataract surgery history and the overall greater prevalence of retinopathy (combined self-reported and observed) in Washington County participants despite the comparable diabetes prevalence between the two communities. The finding that Jackson participants showed greater VA improvement from refraction also supported their lower opportunities of access to eye care. Additionally, the only modest correlation between near and distance presenting VA speaks to the frequent lack of and/or suboptimal near vision correction in this cohort, which could be easily achieved by reading correction.

Visual function seemed to play a more substantial role in physical ability and daily activity outcomes in participants from Jackson than Washington County. There are likely many contributors to the observed differences between the two communities, including differences in community prevalence of VAI, CSI, and the urban (Jackson) and rural (Washington County) community settings such as outdoor and/or social activity engagement, adaptation to VAI and CSI,[46] functional needs,[47] and functional deficits.[48] For example, it may be that older persons with social disadvantages not measured in the current study have more difficulty in adapting to impaired vision, and this factor may explain the different associations between VAI, CSI and physical health across community. Our work highlights the need to interpret such relationships in light of sociodemographic contexts. Further, cross-community research into vision and aging outcomes may open the door to more targeted approaches to mitigating age-related impairment and addressing health disparities.

Strengths and Limitations

The current analysis included a large sample of older Black and White adults from two distinct communities and highlighted their differences in the prevalence of impaired visual function and their associations with multiple aspects of physical health outcomes. We did not deem multiple comparison adjustment appropriate because associations between physical function outcomes and visual function were hypothesized a priori based on the literature review. However, some findings (e.g., mild VAI being associated with better SPPB scores in Jackson) could be due to a type I error. Survival bias is intrinsic with ageing population-based studies and our findings are not necessarily generalizable to populations in other communities with different contextual features. There were additional possible factors that we did not capture that may influence the associations and result in the observed differences between the communities. These factors may be cohort specific rather than community specific and may not be amenable to community-based interventions. Retinal images were obtained in one eye in 90% of the study population, which may result in an underestimation of the occurrence of retinal findings. However, retinal image data were supplemented by incorporating self-reported retinal pathologies. We had poor capture of cataract, the most prevalent eye disease among older adults. The lack of objective data on the presence of cataract has limited further analyses on sources of discrepancies between distance presenting and corrected VA. We were not able to differentiate modifiable from nonmodifiable VAI. Only cross-sectional associations were explored, and we were not able to discern the causal direction of VAI and CSI with physical difficulties. Previous evidence has identified VI as a marker of poor physical functioning over 10 years.[49] However, adults who were physically active have been found to have a lower cumulative incidence of VI, which could suggest behavioral impacts on vision outcomes.[50] Longitudinal and interventional studies are needed to further understand the direction of such associations and whether the prevention of physical limitations can be accomplished through vision correction. Additionally, other aspects of visual function not tested in the current study, for example, visual field and color vision, may be associated with physical health and further research is warranted.

Impaired visual function, common in people 70 years and older, was associated with declined physical health. Such associations were noted to differ across community. Aspects of vision beyond distance VA such as near VA and CS help to maintain functioning. Collectively, the current study confirms the relationships of vision loss with poor physical health and QoL, and call for a better understanding of community-based factors that mitigate the impact of impaired visual function on aging outcomes and emphasize the potential importance of vision screening among older populations to detect correctable vision problems.

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