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BIOLOGICAL RISK OF OLDER ADULTS WITH VISUAL IMPAIRMENTS

B.A. Steinman and S. Vasunilashorn

University of Southern California

Abstract

Objectives—To investigate whether biological markers of health differ among older adults with visual impairment compared to those with normal vision.

Design—We use data from the National Health and Nutrition Examination Survey (1999 – 2006) to investigate clinically defined at-risk levels for 10 biological markers.

Setting—Survey participants were non-institutionalized.

Participants—Nationally representative (U.S.) sample of older adults age 65 and older, categorized as having blindness (20/200 or worse), low vision (20/40 to 20/100) or normal vision (better than 20/40).

Intervention—Separate binary logistic regressions (one for each biomarker, with two at-risk cut points for BMI: obese and underweight) were computed to determine the odds of having at-risk levels of each biomarker.

Measurements—Biomarkers included: systolic and diastolic blood pressure, high-density lipoprotein, low-density lipoprotein (LDL) cholesterol, total cholesterol, glycated hemoglobin, body mass index (BMI), fasting triglycerides, C-reactive protein, and plasma homocysteine.

Results—Older adults who were blind were more likely to have high-risk levels of LDL cholesterol, homocysteine, and to be underweight (BMI > 18.5). Similarly, older adults with LV were more likely to have high-risk levels of homocysteine compared to older adults with normal vision.

Conclusion—As several of the high-risk biomarkers associated with visual impairment were diet-related, our results suggest the importance of nutrition and diet programs aimed towards educating older people who are visually impaired.

Keywords

Visual impairment; biomarkers; nutrition

Introduction

Visual impairments in late life have been widely associated with outcomes pertaining to a range of health-dimensions that influence and reflect the well-being of older adults. In addition to the negative impact of vision loss on functional capacity and physical activity levels (1–3), vision impairment has also been linked to reduced psychosocial wellbeing (4), morbidity (1), self-rated health (5), and even mortality (6–8). In addition, the negative consequences of visual impairment have also been studied with respect to secondary health outcomes such as hospital and emergency room utilization (9), hip fractures (10), and falls (11). Nevertheless, many studies that have examined the health effects of vision

impairments have used only self-reported dimensions of health and functioning in relation to varying degrees of vision acuity.

Far fewer studies have directly compared levels of biological markers of disease in older persons who are blind or visually impaired and non-impaired individuals. Several biomarkers have been associated with higher rates of mortality (12), reduced cognitive (13) and physical (14) functioning, and heart disease (15), and are generally viewed as good indicators of the health status of older people (16), without regard to vision status.

Building on previous epidemiological models of disability(17, 18), Crimmins (19) described biological markers such as cholesterol, body mass index (BMI), markers of inflammation(such as C-reactive protein [CRP]), and indicators of insulin regulation (such as glycated hemoglobin) as risk factors that indicate the underlying health of individuals and their propensity to disease. According to this refined model of the disability process, at the population level, risk factors precede diseases and conditions that lead to functional impairment(including visual impairment), disability, and mortality. For example, glycated hemoglobin— a measure of the average amount of hemoglobin bound to glucose over a prolonged period— could serve as a preclinical indicator of diabetes. Patients with diabetic retinopathy (DR), one of the most common causes of vision loss in older adults, may experience visual impairments which could inhibit their ability to perform activities of daily living (ADLs). With consideration to this trajectory—in which high-risk levels of certain biomarkers precede disease states— older adults, especially those with greater genetic or behavioral risk, could monitor levels as a preventative measure against disease and related disability.

Of the studies that have directly examined relationships between biomarkers and vision loss in older people, most have linked the two via the shared risk profiles of specific eye diseases that occur most frequently in old age and age-related health conditions and systemic diseases outside of the vision system. For example, some types of age-related macular degeneration have been positively associated with high-risk levels of diastolic blood pressure, low-density lipoprotein(LDL) cholesterol, and total cholesterol (20). High levels of systolic and diastolic blood pressure have been linked to increased intraocular pressure and glaucoma (21). Furthermore, the hypothesis that age-related macular degeneration (AMD) is mediated by inflammatory reactions similar to those found in atherosclerosis is supported by studies that show the presence of similar inflammatory markers within retinas affected by AMD. Several studies have reported elevated levels of biomarkers that predict cardiovascular disease (such as fibrinogen, homocysteine, and CRP) in individuals who develop AMD (22, 23). Similarly, levels of CRP have been found to positively correlate with vessel damage in individuals with Type 1 diabetes (24, 25).

Under disease conditions, high-risk levels of some biomarkers would be expected, in part, due to underlying systemic pathologies that result in late-life visual impairment(such as vascular disease and diabetes). However, it is also possible that high-risk levels of some biomarkers could result from behavioral changes that often occur after older individuals become visually impaired. For example, Crews and Campbell(1, 26) reported significant differences between older adults with visual impairments and those with no impairment, in the ability to perform functional tasks, such as walking a quarter mile. Participants who were visually impaired also had significantly greater difficulty performing most ADLs and instrumental activities of daily living (IADLs) compared to participants without visual impairments. These limitations suggest that vision problems in older adults may often precede general declines in overall physical activity that may influence the health and well-being of persons who experience them. Furthermore, older individuals who cannot adequately perform specific daily-living activities such as preparing meals for themselves,

or taking medications could be at greater risk of maintaining poorer health practices, such as eating inadequate or imbalanced diets (26), or mismanaging their single or co-occurring medical conditions (27). Such practices have the potential to negatively affect biological indicators that underlie further disability, loss of functioning, disease, and mortality (16).

The purpose of this study was to examine biological markers of health among older persons with and without visual impairments. Biological markers were chosen because of their underlying clinical relevance, with respect to predicting manifestation of clinical conditions commonly experienced by older adults and associated with poorer physiological functioning. Differences in at-risk levels of biomarkers between vision impairment groups were hypothesized to exist, such that individuals with vision impairment would have at-risk levels of biomarkers compared to normal vision adults.

Method

Data

Data from 1999–2006 of the National Health and Nutrition Examination Survey (NHANES) were analyzed. NHANES uses a complex sampling design in which U.S. counties are the primary sampling unit. The study over-samples persons age 60 and older, in order to provide statistical power to studies of persons in this age group. When variables pertaining to sample weight population strata and cluster are used, NHANES is representative of the noninstitutionalized American population. For this study, we included individuals age 65 and older.

In the demographics section of NHANES IV, information is provided about age, sex, race, educational attainment, and marital status at screening. An examination section provides information collected through physical exams and dietary interview components—this section includes body measurements such as BMI, blood pressure measures, and clinical vision health. Finally, laboratory files contain results from laboratory analyses of blood and urine specimens—and provide information about health risk factors such as cholesterol levels, glycated hemoglobin, fasting triglycerides, CRP, and plasma homocysteine.

Control measures

Five sociodemographic characteristics of participants were controlled including age, gender, education, race, and marital status. Age was coded and analyzed as a continuous variable. Education was coded as a categorical variable with three levels: less than a high school diploma, graduated high school or the equivalent (e.g., completion of the GED), and greater than high school education. Gender, race, and marital status were coded as indicator variables, with “male,” “White,” and “not married” as reference categories, respectively.

Diseases such as diabetes and vascular disease are often directly associated with specific age-related eye diseases (28); therefore an a priori decision was made to control for coronary heart disease (CHD), stroke, and diabetes. Participants of NHANES were asked whether a doctor or other health professional had ever told them that they had CHD, stroke, or diabetes. Responses to these health items were coded into indicator variables with “no” as the reference category.

Independent variables

In addition to five sociodemographic variables and three health variables, a measure of vision acuity was included as the key explanatory independent variable. Vision acuity was recoded into indicator variables according to U.S. definitions of vision impairment. Persons with low vision (LV) (20/40 to 20/100) and blindness (20/200 or worse) in the better-seeing

eye with best correction were compared to a reference group of participants with normal vision (better than 20/40).

Dependent variables

Ten dependent dichotomous variables were computed based on clinically defined at-risk levels for each biological marker (16). The biomarkers included systolic and diastolic blood pressure, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, total cholesterol, glycated hemoglobin, two extremes of body mass index (BMI) (underweight and obese), fasting triglycerides, CRP, and plasma homocysteine. Cut points for some biomarkers remain debated, namely relative to their use in the older adult population (e.g., proposed BMI cut-points used for older adults). The U-shaped relationship of BMI to mortality across age, which has been reported (29) has informed our cutoffs for BMI. The high and low biomarker cut-points used here have also been used in other studies of older adults (16) and have been associated with multiple outcomes, including disability and mortality (29, 30). Defined cutoffs for at-risk levels are shown on Table 2.

Analyses

All analyses were conducted using Statistical Analysis Software (SAS), version 9.1 for Windows. Analyses accounted for the survey design and unequal probabilities of being selected for participation in the study. Basic descriptive statistics, including means and standard deviations, were calculated for sociodemographic variables, vision acuity, and the outcome variables (biomarkers). For all variables including biomarkers, we also computed percentages representing the proportion of individuals at or above high-risk thresholds in each vision category. Chi-square was computed to determine statistically significant differences between vision groups. As an index of effect size, Cramer's V was calculated. According to Green, Salkind, and Akey (31), Cramer's V values of 0.10, 0.30, and 0.50 represent effect sizes that are small, medium, and large, respectively.

To test the effect of vision acuity on the presence of high-risk biomarkers, separate binary logistic regressions (one for each biomarker, with two at-risk cut points for BMI: obese and underweight) were computed using two models. Other methods, including log-binomial regression, were considered but given the relatively low prevalence rate of being at-risk for the biomarkers examined, it was decided that logistic regression models that report odds ratios would be the most appropriate. Model 1 controlled for sociodemographic factors including age, gender, race, education, and marital status. In Model 2, we controlled for coronary heart disease, stroke, and diabetes, in addition to Model 1 covariates. Outcomes are presented as odds ratios (OR) with 95% confidence intervals (CI) reflecting the relative likelihood of being at high-risk for each risk factor by vision status.

Results

Table 1 presents descriptive statistics by visual impairment status for sociodemographic variables, and selected health variables, and biological risk factors. In our sample, about 15% of participants were categorized as having LV, whereas 3% were legally blind. The average age of the entire sample was 74.3 years; persons with LV and blindness were slightly older. The majority of participants were female (57.5%), and among the vision groups, a greater proportion of individuals who are blind were females (63.1%) compared to persons with normal vision or LV. Whereas the majority of the sample was White, the proportion of Hispanics and Blacks in the visual impairment categories, LV and blind, was greater than the category of normal vision, and greater than their representation in the sample. About a third (27.4%) of the sample had attained less than a high school diploma, including 37.8% of persons with LV, and 51.7% of persons who are blind. The majority of

all participants were married (56.0%), whereas less than half (46.7%) of persons with LV and only about a third (32.0%) of participants who were legally blind reported being married. With respect to health variables, significantly greater percentages of persons with visual impairments reported having CHD, stroke, and diabetes. Cramer's V values for all sociodemographic and health variables indicated that statistical differences were based on small effect sizes.

Table 2 displays results of chi square tests that were conducted to assess whether participants differed by vision status with respect to the proportions above biological risk cut points. Results of all tests were significant at less than the .0001 level. With few exceptions, the proportions of persons with LV or legal blindness who had at-risk levels of biomarkers were greater than those with normal vision. With the exception of homocysteine (Cramer's V value of 0.13), all biological variables indicated that statistical differences were based on small effect sizes.

In comparing persons with LV to those with normal vision, the greatest differences in the percentage with high-risk biomarker levels were found for glycated hemoglobin, CRP, homocysteine, high BMI (obesity), and fasting triglycerides. Among these differences, the proportion of obese individuals and individuals with high-risk fasting triglycerides were lower for persons with LV than those with normal vision. On the other hand, in comparing older adults who are blind to those with normal vision, large differences in at-risk levels for several biomarkers were observed. A greater percentage of older adults who are blind exhibited high-risk levels of systolic blood pressure, LDL cholesterol, glycated hemoglobin, CRP, and plasma homocysteine compared to individuals with normal vision. Conversely, a smaller proportion of older adults who are blind had high-risk levels of HDL cholesterol, high BMI (obesity), and triglycerides.

Table 3 presents results of binary logistic regressions conducted to determine the relative odds that persons in each vision impairment category would be at high-risk for each of the ten biological risk indicators. Having LV was statistically associated with diastolic blood pressure, BMI and plasma homocysteine. After controlling for CHD, stroke, and diabetes, persons with LV were about 46% less likely to have high-risk levels of diastolic blood pressure (OR = 0.54; 95% CI 0.34–0.84), and about 30% less likely to be obese (OR = 0.70; 95% CI 0.54–0.90) compared to people with normal vision (Model 2). Low vision was also a statistically significant predictor of being at high-risk for plasma homocysteine; individuals with LV were more than twice as likely to be in this high-risk category (OR = 2.16; 95% CI 1.63–2.85) compared to individuals with normal vision.

After controlling for the 3 previously mentioned health conditions, Model 2 shows that legal blindness was a statistically significant predictor of at-risk levels of HDL cholesterol, fasting LDL cholesterol, obesity, and plasma homocysteine. Participants who are blind were about 69% less likely to have at-risk levels of HDL cholesterol (OR = 0.31; 95% CI 0.16–0.60), but almost 3 times as likely to have high-risk levels of fasting LDL cholesterol (OR = 2.72; 95% CI 1.11–6.68) compared to participants with normal vision. Similar to participants with LV, participants who were blind were less likely to be overweight (OR = 0.56; 95% CI 0.33–0.97) and more than twice as likely to have high-risk levels of plasma homocysteine (OR = 2.19; 95% CI 1.27–3.75) compared to counterparts with normal vision. Although the relationship was not significant, our findings also suggest that older adults who were blind may be at higher risk of being underweight (OR=1.47; 95% CI 0.30–7.29) (Model 2).

Discussion

The purpose of this study was to compare the prevalence of high-risk levels of ten biomarkers of physiological functioning in older persons with visual impairments and those without visual impairments, independent of three common health conditions that could lead to age-related vision pathology. Such a comparison is important, because according to the disability process model outlined by Crimmins (19), risk factors represent the first stage leading to disability, via disease and impairment. Therefore, understanding how older people with visual impairments differ from older adults with normal vision, with respect to biological risk, is an important starting point for understanding how health disparities between the groups could precipitate different health and functioning outcomes. In addition, knowledge about biological risks associated with LV and blindness could lend insight to policy decisions about which types of services should be prioritized for older adults with visual impairments.

Our results indicated that visual impairments were associated with several biological risk predictors. Based on our guiding hypotheses, we expected that there would be differences. Whereas our analyses were based on cross-sectional data and we cannot determine the causality of the at-risk biomarker levels shown here, it is possible that our results derive from at least two potential explanations. First, the disparities in biomarkers among the three vision status groups may be due to changes in diet and activity levels that often follow the onset of vision loss in late life (1). Functional losses, in general, inherently suggest that older adults who experience them will be less physically active. Older persons with varying degrees of vision loss, have been reported to experience greater declines in their ability to perform functional activities (3, 26, 32–35). For example, Hassell, Lamoureux, and Keeffe (35) found that older adults with even mild degrees of vision loss due to macular degeneration, a visual condition that impacts central vision, often struggled with many common daily activities. Some specific measures of ADLs and IADLs that are typically used to quantify disability in older people place direct emphasis on activities that would influence the dietary choices of persons who could not perform them independently (such as the ability to eat, to prepare meals for themselves, or to shop for groceries without assistance). Consistent with this view, our results indicated that older adults with vision impairments are less likely to be overweight, and may be at greater risk for being underweight. Functional difficulties, over a long enough period of time, would likely affect other aspects of an individual's health, starting by reducing physical activity and dietary quality, and consequently exerting negative influence on specific biomarkers that reflect the individual's dietary practices and activity levels.

Second, the differences in at-risk levels of biomarkers may be a reflection of other pathologies and conditions that are either directly or indirectly related to poor visual acuity. As previously mentioned, this is likely the case, but may not be the sole reason for the differences in biological risk found in the current study. We further acknowledge the role of disease states in our investigation of the biomarker to vision acuity relationship. Disease states may likely be found along the continuum of the biomarker to visual impairment pathway and adjusting for these conditions modifies the relationship for some of the biomarkers examined. Ultimately, we speculate that disparities in biological risk factors can be explained by both differences in the processes underlying vision status (and any potentially related comorbidities), as well as by behavioral factors that likely place older adults who are visually impaired at greater risk for precursors related to at-risk levels of these biological indicators.

Differences in risk among the blood lipid parameters for blind individuals were also found. Whereas older adults who are blind were at greater risk of having high levels of total

cholesterol compared to the normal vision group, they had a lower risk of having at-risk (or low) levels of HDL-cholesterol. Differences in cholesterol findings were also reported among older adults participating in the MacArthur Study of Successful Aging and for adults age 40+ in the NHANES III (36, 37).

The elevated levels of homocysteine exhibited in both LV and blind individuals were among the most interesting of our findings. The mechanisms by which vision loss and high-risk levels of homocysteine interact could be explained in part by diet and lifestyle circumstances. One important factor that is known to determine homocysteine concentration is nutrition, and it has been suggested that elevated levels of plasma homocysteine are indicative of poor nutrition (38, 39). For older adults with visual impairment, this finding is especially important given the associations reported between elevated plasma homocysteine levels and increased risk of other negative health outcomes, including cardiovascular disease (40–42), depression (43), Alzheimer's disease (44, 45), and colorectal cancer (46). Given that a portion of homocysteine levels can be attributed to nutrition, diet modifications that include adequate amounts of folate and vitamins B6 and B12 could potentially improve the health of individuals with visual impairments or any individuals with inadequate nutrient intake. Folate, vitamin B6, and vitamin B12 play important roles in homocysteine metabolism, such that deficiencies in any or in all have been associated with elevated levels of total homocysteine (39, 47–49). However, vitamin use or levels of circulating vitamins (e.g., B-vitamins) alone may not be associated with cardiovascular outcomes (50). It may be that a broader array of nutrition and lifestyle changes, aside from greater intake of B-vitamins, is important in determining the onset of adverse health outcomes.

Thus, focusing on rehabilitation treatments that improve diet to reduce high-risk levels of specific biomarkers in older adults with visual impairments has the potential to exert positive influence on an array of health factors. Vitamin supplementation or enhanced nutrient-rich diets for visually impaired individuals may be one affordable and efficient way to address the potential specific health risks experienced by this group of high-risk individuals. Extant nutrition programs that are administered by the Administration on Aging (AoA) and implemented locally by area agencies on aging (AAA) and contracted agencies have the potential to function as effective vessels for targeting older adults with visual impairments for special diets and disseminating dietary information related to specific biomarkers. Consumers with visual impairments (as well as older adult consumers in general) might benefit from the option of special diets that address the issue of elevated homocysteine and cholesterol levels, (similar to low-salt diets offered to control hypertension), as well as body weight. In addition, rehabilitation services, such as those provided by state/federal independent living programs for older individuals who are blind can serve a vital purpose in training older adults with visual impairments to maintain ADL/IADL functioning that is crucial to their health and well-being. These services, in particular have been shown to be effective in helping older adults complete daily functional activities independently, including preparing meals for themselves, and continuing to participate in the lives and activities of family, friends and their communities (51).

In this study, our goal was to demonstrate relationships between low vision acuity (or blindness) and specific biomarkers that could influence the health status of older adults. Although the findings of this study are believed to reflect these associations accurately, it is recognized that the study has at least one important limitation, which we have previously mentioned. The relationship between vision and health is complicated because it is often difficult, if not impossible to determine directionality—that is, to sort out the extent to which vision loss causes changes in biomarkers that often precede chronic diseases (as hypothesized); versus the extent to which chronic diseases may lead to vision loss. Unfortunately, the use of cross sectional data was limiting in our study, because it did not

provide the opportunity to assess the temporal order of these important events. It is possible that at-risk levels of some biomarkers could exist prior to vision loss or as a result of chronic diseases (such as diabetes or vascular disease), which often result in vision loss. To acknowledge this limitation, we controlled several health conditions that are known to be related to visual impairment in our final models, to assure that the presence of disease was considered separately from the effects of visual acuity, per se. Although a more rigorous longitudinal analysis would take into consideration the timing of key events to make a more powerful assertion of causality, results of this study, nevertheless, point to important differences between older persons with normal vision and those with vision impairment.

Fortunately, poor nutrition and decreased activity levels that often accompany vision impairment in late life, and may affect many of the biomarkers examined in this study, can be addressed through relatively simple and inexpensive interventions within programs that serve this population. Nutrition programs that serve older adults in general, as well as rehabilitation programs that target services toward the population of older persons with visual impairments can benefit by increasing awareness of how certain health dimensions may be experienced differently by older persons who are visually impaired.

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Table 1

Descriptive Statistics for Sociodemographic variables by Visual Impairment (NHANES, 1999 – 2006)

	Normal (n = 3404)	LV (n = 849)	Blind (n = 130)	Total (N = 4383)	P	Cramer's V
% total	77.7%	15.3%	3.0%	100.0%		
Age (mean yrs.)	72.9	76.7	78.4	74.3	***	0.20
Female	55.6%	56.5%	63.1%	57.5%	***	0.02
Race						
White	86.0%	74.7%	72.0%	83.0%	***	0.09
Hispanic	4.9%	11.0%	11.7%	6.1%		
Black	7.0%	10.2%	12.8%	8.0%		
Other	2.1%	4.1%	3.5%	2.9%		
Education						
< High school	22.4%	37.8%	51.7%	27.4%	***	0.11
High school	34.3%	32.8%	28.4%	33.8%		
> High school	43.3%	29.4%	19.9%	38.9%		
Married	62.5%	46.7%	32.0%	56.0%	***	0.14
Coronary Heart Disease	11.8%	14.4%	14.1%	12.1%	***	0.03
Stroke	7.3%	9.9%	18.0%	9.1%	***	0.06
Diabetes	15.3%	20.4%	23.5%	16.7%	***	0.06

LV=low vision;

p<.0001

Table 2
Descriptive Statistics for Biological Risk Indicators by Vision Status (NHANES, 1999 – 2006)

Indicator	Normal (n = 3404)	LV (n = 849)	Blind (n = 130)	Total (N = 4383)	P	Cramer's V
	At Risk Cut Point			Percent At-Risk		
Diastolic blood pressure	>90 mmHg	2.6%	5.7%	4.2%	***	0.03
Systolic blood pressure	>140 mmHg	47.5%	59.3%	44.6%	***	0.05
HDL cholesterol	<40 mg/dl	15.4%	6.0%	15.6%	***	0.04
Fasting LDL cholesterol	>160 mg/dl	12.1%	29.0%	12.8%	***	0.07
High total cholesterol	<240 mg/dl	19.4%	24.5%	19.2%	***	0.02
Low total cholesterol	<160 mg/dl	13.5%	7.2%	12.7%	***	0.03
Glycated hemoglobin	>6.4%	14.1%	21.0%	10.9%	***	0.05
Obese (BMI)	>30 kg/m2	24.9%	23.5%	29.8%	***	0.05
Under weight (BMI)	<18.5 kg/m2	1.9%	2.6%	1.6%	***	0.02
Fasting triglycerides	>200 mg/dl	19.0%	13.7%	21.7%	***	0.04
C-reactive protein	>4.0 mg/l	37.7%	39.1%	33.9%	***	0.05
Plasma homocysteine	>15 mmol/l	22.0%	24.2%	13.0%	***	0.13

LV = low vision; BMI = body mass index; HDL = high-density lipoproteins; LDL = low-density lipoproteins;

p<.0001

Table 3
Regression Models Testing the Effect of Vision Status on Biological Risk Indicators (NHANES, 1999 – 2006)

Indicator	At-Risk Cut Point	N (models 1/2)	Low Vision				Blind			
			Model 1 [*]	95% CI	OR ^{**}	95% CI	Model 2 [†]	95% CI	OR ^{**}	95% CI
Diastolic blood pressure	>90 mmHg	4121/4047	0.51	(0.33–0.80)	0.54	(0.34–0.84)	1.15	(0.41–3.21)	1.25	(0.44–3.56)
Systolic blood pressure	>140 mmHg	4121/4047	1.12	(0.93–1.36)	1.12	(0.93–1.35)	1.67	(1.02–2.76)	1.51	(0.91–2.52)
HDL cholesterol	<40 mg/dl	4046/3972	0.87	(0.63–1.21)	0.81	(0.58–1.14)	0.32	(0.16–0.62)	0.31	(0.16–0.60)
Fasting LDL cholesterol	>160 mg/dl	1815/1783	0.86	(0.53–1.40)	0.92	(0.57–1.48)	2.34	(0.96–5.68)	2.72	(1.11–6.68)
High total cholesterol	>240 mg/dl	4047/3973	0.94	(0.74–1.20)	0.99	(0.79–1.25)	1.17	(0.60–2.27)	1.28	(0.66–2.51)
Low total cholesterol	<160 mg/dl	4047/3973	1.09	(0.81–1.46)	1.04	(0.76–1.42)	0.54	(0.24–1.22)	0.51	(0.22–1.22)
Glycated hemoglobin	>6.4%	4277/4198	1.11	(0.84–1.48)	0.90	(0.61–1.32)	1.82	(1.07–3.09)	1.22	(0.54–2.76)
Obese (BMI)	>30 kg/m ²	4130/4053	0.74	(0.58–0.94)	0.70	(0.54–0.90)	0.70	(0.41–1.21)	0.56	(0.33–0.97)
Underweight (BMI)	<18.5 kg/m ²	4130/4053	0.93	(0.45–1.95)	0.97	(0.46–2.02)	1.41	(0.31–6.32)	1.47	(0.30–7.29)
Fasting triglycerides	>200 mg/dl	1956/1922	0.80	(0.54–1.19)	0.75	(0.50–1.13)	0.57	(0.25–1.31)	0.61	(0.26–1.43)
C-reactive protein	>4.0 mg/l	4066/3992	0.81	(0.64–1.01)	0.82	(0.66–1.03)	0.80	(0.53–1.21)	0.80	(0.53–1.21)
Plasma homocysteine	>15 mmol/l	3136/3073	2.20	(1.69–2.86)	2.16	(1.63–2.85)	2.10	(1.21–3.66)	2.19	(1.27–3.75)

Note:

^{*} Model 1 controlled for age, gender, race, education, marital status;

[†] Model 2 controlled for age, gender, race, education, marital status, coronary heart disease, stroke, and diabetes;

^{**} Odds Ratio (OR) with Normal vision as the reference group; Bold items indicates significant at the p<.05 level;

CI = confidence interval; HDL = high-density lipoprotein; LDL = low-density lipoprotein; BMI = body mass index to after “LDL = low-density lipoprotein,” and replace “lipoproteins” with “lipoprotein” so that it reads, “LV = low vision; HDL = high-density lipoprotein; LDL = low-density lipoprotein; BMI = body mass index;

^{***} p<.0001