Binocular Visual-Field Loss Increases the Risk of Future Falls in Older White Women

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OBJECTIVES: To examine the relationship between binocular visual field loss and the risk of incident frequent falls in older white women.

DESIGN: A multicenter, prospective cohort study.

SETTING: Four clinic centers within the United States in Baltimore, Maryland; Minneapolis, Minnesota; Portland, Oregon; and the Monongahela Valley, Pennsylvania.

PARTICIPANTS: Four thousand seventy-one community-dwelling white women aged 70 and older participating in the Study of Osteoporotic Fractures.

MEASUREMENTS: Primary outcome was incident frequent falls, defined as two or more falls within 1 year. Primary risk factors were binocular visual field loss, distance visual acuity in the better eye, and contrast sensitivity at low spatial frequency in the better eye.

RESULTS: Of 4,071 women, 409 (10%) had severe binocular visual field loss at the eye examination, and 643 (16%) experienced frequent falls within 1 year after their eye examination. Severe binocular visual field loss was significantly associated with frequent falls when adjusting for age, study site, and cognitive function (odds ratio = 1.50, 95% confidence interval = 1.11–2.02). The data showed a trend for increasing odds of two or more falls with greater binocular visual field loss ($P < .001$). In older white women with severe binocular visual field loss, 33.3% of frequent falls were attributable to visual field loss.

CONCLUSION: Women with binocular visual field loss are at greater risk of future frequent falls. Screening for binocular visual field loss may identify individuals at high risk of falling. **J Am Geriatr Soc 55:357–364, 2007.**

Key words: Binocular visual field loss; falls; older white women

Falls in older adults are a major public health concern[1–5] because of their frequency, the associated morbidity and mortality, and the healthcare costs of hospitalization and treatment. Studies estimate that between 30% and 40% of community-dwelling adults aged 65 and older experience falls each year.[6–9] Approximately 30% of older adults who fall suffer serious injuries.[10] Falls were the leading cause of unintentional injury death for individuals aged 65 and older in 2003.[11] The incidence of falls increases steadily with age,[5] and women are at greater risk of suffering fall-related injuries.[12]

Evidence suggests that high risks of falls are associated with poor vision.[13,14] Visual impairment may compound or cause falls.[13] Standard tests of visual acuity and contrast sensitivity (CS) have been used to determine tendency to fall. CS, the ability to discern small changes in contrast or to see objects and separate them from the background, has been associated with a high risk of falls.[15,16] Some studies have reported that visual acuity, assessing the ability to resolve fine details, is also associated with likelihood of frequent falling,[15–19] whereas others have not indicated a strong relationship between visual acuity and falling.[20–22]

Visual acuity and CS as single measures of visual impairment may not be sufficient to determine the risk of falls,[23] because other measures, including visual field

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loss, affect visual functioning. Visual field loss is a measure of decreased or no perception of light in central or peripheral vision. As such, visual field measurement is a standard diagnostic tool for disorders of the visual pathway that translates visual signals from the eye or retina to the brain.

Studies examining the association between visual field loss and frequent falling are limited and inconclusive.[15,16,24–26] Although studies have reported an association between visual field loss in one eye and frequent falling, none of them has shown an association between binocular visual field loss and falls. Binocular visual fields represent how a person functions in the world because the visual fields in both eyes almost completely overlap one another. The current study examined the association between binocular visual field loss and frequent falls in 4,071 older white women in the Study of Osteoporotic Fractures (SOF). Previous reports from the SOF assessed the association between visual impairment and hip[27] and wrist fractures.[28]

METHODS

Subjects

A total of 9,704 community-dwelling white female volunteers, aged 65 and older, with no previous history of bilateral hip replacement completed their baseline visit for the SOF, a multicenter, prospective longitudinal cohort study, from 1986 to 1988. The participants were located at four clinic centers within the United States: Baltimore, Maryland; Minneapolis, Minnesota; Portland, Oregon; and the Monongahela Valley, Pennsylvania. Between January 1997 and September 1998, all surviving participants were invited to take part in a follow-up clinical examination (referred to as the sixth clinic visit), which included a comprehensive eye examination. All individuals in the study signed informed consent forms to participate in the sixth clinic visit. Institutional review board approvals were obtained from all participating centers before the study. One of the purposes of the study was to measure the association between falls and various components of vision, including visual field loss, CS, and visual acuity. A total of 4,820 women attended the sixth clinic visit. Of these, 4,071 (84%) had reliable visual field tests in both eyes and provided information on subsequent falls during the first year of follow-up (Figure 1).

Assessment of Vision

Visual field tests were performed on both eyes of each participant separately using the Humphrey Field Analyzer suprathreshold 76-point 30° visual-field program (Humphrey Field Analyzer, Zeiss, Oberkochen, Germany).[29] The suprathreshold 76-point program is a screening visual field test measuring whether the eye's visual pathway detects a light 6 dB brighter than that which an eye of a normal subject who is the same age could detect. A total of 76 points are present in the central and peripheral fields of each eye. Examiners were trained for half a day in the use of the Humphrey Perimeter Analyzer. The training session covered the calibration of the perimeter, the choice of the corrective lenses used for the test, and the explanation of the

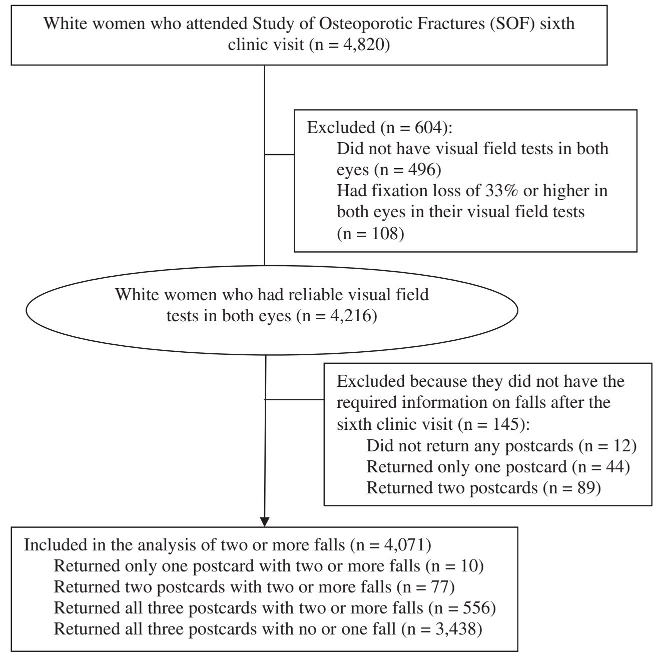

Figure 1. Study participant flow chart.

test to subjects. The examiners then performed screening visual field tests on volunteers, and study coordinators or investigators certified them when they were proficient in the examination technique.

Because the 76-point screening visual field test indicates only whether the light was seen in a specific area, the binocular visual field of each participant was created by overlapping the two 76-screening visual fields for each eye, using a method adapted from Esterman's binocular visual field functional scoring algorithm (Figure 2).[30] The right and left eyes' visual fields were overlapped in the central and nasal areas, creating a 96-point binocular visual field. Binocular visual field loss was then defined as the inability to see light in both eyes at one or more points in this 96-point field. Points that were lost in the temporal, nonoverlapped areas correspond to loss in the temporal field of one eye (the location where there is no redundancy of the field in both eyes). Points that were lost in the overlapped areas (central and nasal field for both eyes) correspond to the loss of light sensitivity in the same area in both eyes. Participants who did not have visual field tests in both eyes (n = 496) or who had unreliable visual field tests, defined as fixation losses of 33% or higher in the visual field tests in both eyes (n = 108) were excluded from the analysis (Figure 1).

Distance visual acuity was measured in each eye separately with habitual correction under standard illumination using Bailey-Lovie charts. These charts are similar to the Early Treatment Diabetic Retinopathy charts in that the lines are of equal difficulty and that there is geometric progression in letter size from line to line. The number of letters seen correctly was recorded. CS was also measured in each eye separately with habitual correction under standard illumination using the VCTS 6500 charts (Vistech Consultants, Inc., Dayton, OH). These charts present a series of sine wave gratings at calibrated levels of contrast at specific spatial frequencies (cycles per degree). The number of grat-

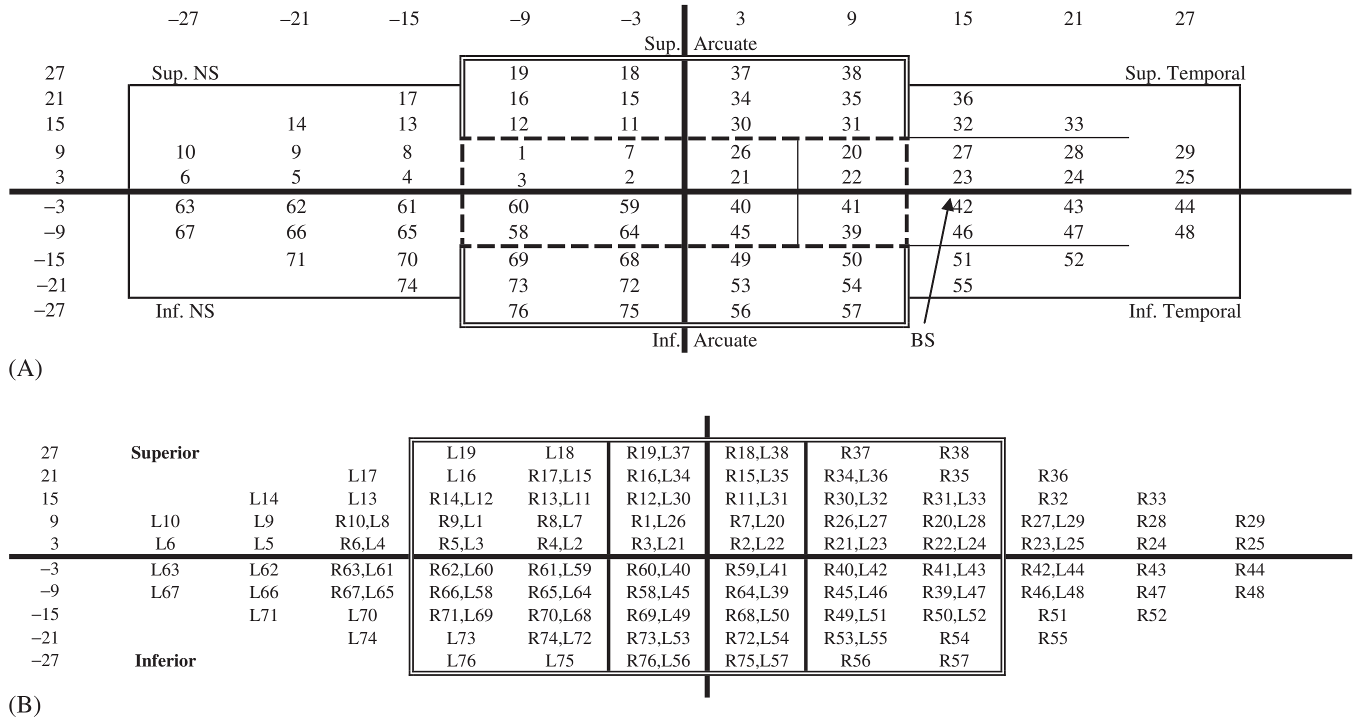

Figure 2. Layout of binocular visual field. (A) The Humphrey 76-point suprathreshold screening visual field test for the right eye. (B) The 96-point binocular visual field by overlapping visual fields at central and nasal areas from two eyes (shift left eyes two columns to the left), adapted from Esterman's 100-point binocular visual field functional scoring algorithm. A point lost in the binocular visual field in the overlapped area means that both eyes missed the location. BS = blind spot; NS = nasal; Inf = inferior; Sup = superior.

ings seen correctly was recorded and converted to a CS score at each spatial frequency according to the manufacturer's manual.

Other Measurements

In addition to vision-related measurements, other clinical characteristics were collected. Participants rated their health relative to others into one of five categories: excellent, good, fair, poor, or very poor. The responses were categorized into two groups of self-rated health: (1) fair, poor, or very poor and (2) excellent or good. Cognitive function was measured using the Mini-Mental State Examination, as described previously.[31]

Ascertainment of Falls

All women were contacted by postcard or telephone approximately every 4 months to establish whether they had experienced any falls. A cumulative completion rate of 98% for these contacts has existed since the inception of SOF.[32] Falls were measured by asking participants whether they had fallen to the floor or hit an object when falling in the past 4 months.[27] All falls reported on the first three triannual postcards returned after the vision examination (covering approximately 1 year of follow-up) were included in this analysis. Participants who had only one or two postcards (instead of all three) during this time were included in the analysis only if they reported two or more falls on the completed postcard(s). Otherwise, these participants were excluded from the analysis because their fall status could not be determined. In this study, incident frequent falling was defined as two or more falls within 1 year after the clinical examination versus fewer than two falls.

Statistical Analysis

Statistical software SAS version 9.1 (SAS Institute, Inc., Cary, NC) was used for all analyses. The primary objective of the analysis was to determine associations between measures of visual field deficit and frequent falls. The number of points missed in the binocular visual field was summed to obtain the total number of points missed. Because the distribution of visual field loss was highly skewed, binocular visual field loss was categorized into four groups: 0 points missed, 1 to 9 points missed (mild visual field loss), 10 to 19 points missed (moderate visual field loss), and 20 or more points missed (severe visual field loss). Inferior and superior binocular visual field loss were evaluated in secondary analysis, and they each were categorized as no visual loss (0 points missed) mild (1–4 points missed) moderate (5–9 points missed) and severe ($\geq$10 points missed). Visual acuity in the better eye was dichotomized into Snellen visual acuity levels of worse than 20/40 and 20/40 or better. CS in the better eye at low spatial frequency (1.5 cycles/degree) was categorized as CS score of less than 25 and CS score of 25 or greater. When information was not available for at least one eye at 1.5 cycles/degree, CS values for 3 cycles/degree were used.

The association between binocular visual field loss and falls was evaluated employing multiple logistic regression models. The unadjusted risk of falls and the risk of falls controlled for age, site, and cognitive function associated with binocular visual field loss, decreased visual acuity, and poor CS were assessed. Because of the statistically significant correlations between binocular visual field loss, visual acuity, and CS (Spearman correlation coefficients of 0.17 for binocular visual field loss and visual acuity ($P < .001$), 0.20 for binocular visual field loss and CS ($P < .001$), and 0.44 for visual acuity and CS ($P < .001$)), more than one vision parameter was not included in the same logistic regression model.

In addition, the interactions between binocular visual field loss and age were evaluated for the prediction of fall outcomes. The percentage attributable risk and the population attributable risk percentage for binocular visual field loss were calculated.[33] The percentage attributable risk measures the fraction of incident frequent falls in women with severe binocular visual field loss that is attributable to their visual field loss. The population attributable risk percentage measures the fraction of incident frequent falls in all older white women that is attributable to their severe binocular visual field loss.

In a secondary sensitivity analysis, binocular visual field loss, visual acuity in the better eye, and CS in the better eye at low spatial frequency were also analyzed as continuous variables in the regression models. To control for the skewness and extreme values, the continuous binocular visual field loss variable was analyzed as the number of points lost, except for women who lost more than 40 points, for whom 40 was assigned as their values of binocular visual field loss; the transformation is close to the rank transformation of the binocular visual field loss; the continuous visual acuity variable was analyzed as the number of letters read correctly in the better eye, which is a logarithmic transformation of Snellen visual acuity; and the continuous CS variable was analyzed as a logarithmic transformation of CS score in the better eye at low frequency. All three continuous vision variables were then standardized according to their standard deviation (SD) after the transformation, and the results were presented as odds ratios of frequent falls per one SD change.

RESULTS

A total of 4,820 women attended the sixth clinical visit between January 1997 and September 1998. By April 2005, they had an average $\pm$ SD length of follow-up of 7.3 ± 0.5 years. Of them, 4,216 women had reliable visual field tests in both eyes. Table 1 summarizes the characteristics of these participants, including their age, visual acuity and low-frequency CS in the better eye, self-rated health status, history of falls, cognitive function, and self-reported diabetes mellitus and eye diseases. Women with reliable visual field tests in both eyes tended to be slightly younger and had better self-rated health status, better cognitive function, superior visual acuity and low-frequency CS in the better eye, and lower prevalence of self-reported glaucoma and age-related macular degeneration (AMD) than women who did not participate in the visual field test or had only one eye examined (Table 1). Of 4,216 women with reliable visual field tests in both eyes, 1,046 (25%) had visual acuity in the better eye worse than 20/40, 475 (12%) had a CS score less than 25 in the better eye, 775 (18%) rated their health status as fair or poor, 199 (5%) reported having diabetes mellitus, 461 (11%) reported having glaucoma in at least one eye, and 430 (10%) reported having AMD in at least one eye.

Of the 4,216 women, 145 were excluded from the analysis measuring the risk of falls, because they did not provide adequate information regarding incident falls. A total of 4,071 women had reliable visual field tests in both eyes and provided information on falling the subsequent year. The range of missed points on the binocular visual field test was 0 to 87, with a mean of 6.3 ± 11.5. A total of 1,538 women (38%) missed no points on the test, and 1,714 (42%) had mild binocular visual field loss. Four hundred ten (10%) women had moderate binocular visual field loss, and 409 (10%) had severe binocular visual field loss.

Within 1 year after the sixth clinical visit, 643 of the 4,071 women (16%) reported experiencing at least two falls; 13% of women with no binocular visual field loss reported frequent falling, compared with 16%, 19%, and 22% of women with mild, moderate, and severe binocular visual field loss, respectively. This trend of increased frequent falling with greater visual field loss was statistically significant ($P < .001$).

In unadjusted and adjusted analyses, women with severe binocular visual field loss had greater odds of frequent falling than women with no binocular visual field loss (Table 2). In unadjusted analyses, the odds of frequent falling were 98% greater in women with severe binocular visual field loss than women with no visual field loss (odds ratio (OR) = 1.98, 95% confidence interval (CI) = 1.50–2.60). This excess risk was attenuated after controlling for age and study site to 60% greater odds of frequent falling in women with severe binocular visual field loss than in women with no visual field loss (OR = 1.60, 95% CI = 1.19–2.14). When cognitive function was also controlled for, women with severe binocular visual field loss had 50% greater odds of frequent falls (OR = 1.50, 95% CI = 1.11–2.02) than women with no binocular visual field loss.

Increasing visual field loss in the lower (inferior) or upper (superior) regions of the visual field was significantly associated with higher rates of frequent falling ($P < .001$) as well. Women with severe inferior visual field loss had 91% greater odds of frequent falls than women with no inferior visual field loss (OR = 1.91, 95% CI = 1.05–1.56), whereas women with severe superior visual field loss had 74% greater odds of frequent falls (OR = 1.74, 95% CI = 1.36–2.23).

In unadjusted analysis, CS was a significant risk factor for two or more falls, although the association was not statistically significant when adjusting for age, study site, and cognition. There was no statistically significant association between visual acuity and at least two falls in unadjusted or adjusted analyses (Table 2).

In analyses incorporating interactions between binocular visual field loss and age, the elevated likelihood of frequent falls in women with binocular visual field loss was more pronounced for women in their 80s than for women in their 70s, although this reflected increasing risk of frequent falls for both increasing age and more-severe binocular visual field loss, and the interaction was not statistically significant ($P = .92$). There were also no interaction effects

Table 1. Baseline Characteristics of White Women Who Participated in the Study of Osteoporotic Fractures Clinic Visit According to Status of Visual Field (VF) Test (N = 4,820)

	VF Measured in Both Eyes				
Characteristic	Reliable in at Least One Eye (n = 4,216)	Unreliable in Both Eyes (n = 108)	VF Measured in One Eye (n = 221)	No VF Measured in Either Eye (n = 275)	*P*-value*
Study site, n (%)					<.001
Baltimore	988 (23)	16 (15)	35 (19)	58 (21)	
Minneapolis	1,311 (31)	37 (34)	65 (29)	71 (26)	
Pittsburgh	1,028 (24)	35 (32)	84 (38)	85 (31)	
Portland	889 (21)	20 (19)	37 (17)	61 (22)	
Age					
Mean ± SD	79.9 ± 4.0	79.8 ± 4.3	81.4 ± 4.8	81.9 ± 5.1	<.001
<80, n (%)	2,301 (55)	61 (56)	92 (42)	103 (37)	<.001
80–84, n (%)	1,358 (32)	33 (31)	73 (33)	96 (35)	
≥85, n (%)	557 (13)	14 (13)	56 (25)	76 (28)	
Habitual distance visual acuity in the better eye (number of letters, 0–70)					
Mean ± SD	46.2 ± 7.5	45.1 ± 10.6	39.0 ± 14.1	38.3 ± 16.8	<.001
20/40 or worse, n (%)	1,046 (25)	24 (22)	102 (47)	82 (37)	<.001
Low-frequency (1.5 or 3 cycles/degree) CS in the better eye (CS score, 0–220)					
Mean ± SD	61.0 ± 36.1	58.2 ± 35.6	50.8 ± 34.8	53.2 ± 39.5	<.001
Less than 25, n (%)	475 (12)	16 (15)	14 (23)	50 (26)	<.001
Self-rated health status, n (%)					.04
Fair/poor/very poor	775 (18)	23 (21)	51 (23)	66 (24)	
Excellent/good	3,437 (82)	85 (79)	169 (77)	208 (76)	
Mini-Mental State Examination score (range 6–30) mean ± SD	28.0 ± 2.0	27.7 ± 2.5	27.8 ± 2.2	26.9 ± 3.4	<.001
Fall in last year, n (%)	1,284 (31)	35 (32)	76 (35)	102 (37)	.08
Self-reported diabetes mellitus, n (%)	199 (5)	7 (6)	16 (7)	6 (2)	.05
Self-reported glaucoma in at least one eye, n (%)	476 (11)	9 (8)	59 (27)	44 (16)	<.001
Self-reported treatment for glaucoma, n (%)	461 (11)	9 (8)	56 (25)	43 (16)	<.001
Self-reported AMD in at least one eye, n (%)	430 (10)	13 (12)	80 (36)	76 (28)	<.001
Self-reported treatment for AMD, n (%)	13 (0.3)	1 (1)	11 (5)	9 (3)	<.001
Self-reported cataract in at least one eye, n (%)	3,047 (72)	70 (65)	166 (75)	198 (72)	.27
Self-reported cataract surgery in at least one eye, n (%)	1,722 (41)	47 (44)	110 (50)	135 (49)	.004

* Chi-square, analysis of variance and Kruskal-Wallis tests used because of nonnormal distribution.
SD = standard deviation; CS = contrast sensitivity; AMD = age-related macular degeneration.

between visual acuity in the better eye and binocular visual field loss ($P = .42$) and CS in the better eye and binocular visual field loss ($P = .39$).

Using the fully adjusted OR of 1.50 as the relative risk of frequent falls for severe binocular visual field loss compared with no such loss, the percentage attributable risk of frequent falls from severe binocular visual field was 33.3%. Assuming that 10% of all older white women had severe binocular visual field loss, the population attributable risk percentage of frequent falls from severe binocular visual field loss was 4.8%.

In the secondary sensitivity analysis, when continuous vision variables were analyzed, women with more points lost in the binocular visual field had higher odds of frequent falls in the unadjusted analysis (OR = 1.19 per SD, 95% CI = 1.11–1.29) and the analysis adjusted for age, study site, and cognition (OR = 1.11 per SD, 95% CI = 1.02–1.20). Women with better visual acuity in the better eye had lower odds of frequent falling in the unadjusted analysis (OR = 0.91 per SD, 95% CI = 0.84–0.98), but the effect diminished after controlling for age, study site, and cognition (OR = 1.03 per SD, 95% CI = 0.94–1.12). Women with better CS at low frequency in the better eye had lower odds of frequent falling in the unadjusted analysis (OR = 0.81 per SD, 95% CI = 0.74–0.88) and the analysis adjusted for age, study site, and cognition (OR = 0.89 per SD, 95% CI = 0.81–0.98).

DISCUSSION

Binocular visual field loss increases the risk of future frequent falls in older white women. The more severe the

Table 2. Association Between Binocular Visual Field Loss (BVFL), Visual Acuity, and Contrast Sensitivity and the Risk of at Least Two Falls (N = 4,071)

	Risk of at Least Two Falls		
	Unadjusted	Adjusted for Study Site and Age	Adjusted for Study Site, Age, and Cognitive Function
Vision Risk Factors	Odds Ratio (95% Confidence Interval) *P*-value		
BVFL (number of points missed)			
None (0)	Ref (1)	Ref (1)	Ref (1)
Mild (1–9)	1.30 (1.07–1.59) .009	1.20 (0.98–1.47) .07	1.17 (0.95 –1.43) .14
Moderate (10–19)	1.63 (1.22–2.17) < .001	1.42 (1.06–1.90) .02	1.37 (1.01–1.84) .04
Severe (20+)	1.98 (1.50–2.60) < .001	1.60 (1.19–2.14) .002	1.50 (1.11–2.02) .008
Visual acuity worse than 20/40 vs 20/40 or better	1.06 (0.88–1.29) .53	0.86 (0.70–1.06) .15	0.82 (0.66–1.00) .05
Contrast sensitivity less than 25 vs 25 or better	1.56 (1.22–1.99) < .001	1.25 (0.97–1.62) .09	1.22 (0.94–1.58) .13

visual field loss is, the greater the risk of recurrent falling. The association was independent of age, study site, and cognition. One-third (33.3%) of frequent falls in women with severe binocular visual field loss was attributable to their severe binocular visual field loss. To the best of the authors' knowledge, this is the first prospective study showing a greater risk of incident frequent falling in older women with greater binocular visual field loss.

Ocular diseases, such as glaucoma, cataracts, and retinal disease in both eyes, or a tumor or vascular occlusion along the cerebral visual pathway can cause binocular visual field loss. Women with severe binocular visual field loss were more likely to report having glaucoma or AMD in at least one eye (20% and 16%, respectively) than women with no binocular visual field loss (9% and 7%, respectively). Although treatment for AMD is limited, glaucoma and cataracts can be treated successfully. In addition, mobility training could help decrease the risk of falls in individuals with binocular visual field loss. Even though visual field testing is usually performed in an ophthalmologist's office, the screening tests can be easily adapted for other settings because nonophthalmic technicians or nurses can perform them after 8 hours of training or less. The total test time for a subject is 4 minutes or less. In SOF, only 2.5% (108/4,324) of women who had their visual fields examined were excluded because the results were unreliable.

Although there have been several studies that have investigated the association between visual fields and falls, only two have prospectively followed subjects after the examination of the visual field. One[16] sent monthly questionnaires to 148 subjects for a year after evaluating the inferior field with a test described as lower visual field size. In this test, individuals were asked to open their eyes and look directly and continually at a circular target on the floor and point to a black square card if they could see any part of it "out of the corner of their eye." The investigators stated that the reliability of this test was unclear. This test is not routinely used in the offices of eye care providers and has not been validated in other populations of which the authors are aware. The study found that the association between visual field loss and falls was not as strong as the association between falls and measures of visual acuity, CS, and depth perception. In the current study, binocular visual field loss and CS were moderate risk factors for frequent falls.

The other prospective study was the Rotterdam Study,[34] in which investigators asked 6,280 subjects 3.8 years after their visual field assessment whether they had fallen more than four times in the previous 2 years. Visual field loss was identified using two visual field testing strategies, with roughly two thirds of visual field loss subjects identified using the Goldman visual field test (a manual perimetry test) and the other third identified using a 52-point suprathreshold test (an automated perimetry test). In contrast, the current study used a standardized automated visual field testing protocol on every participant. Binocular visual fields, which probably are more representative of a subject's visual functioning, were not calculated in the Rotterdam Study, which instead evaluated bilateral visual field loss, which is any visual field loss that is present in both eyes without consideration of whether the locations of visual field loss overlapped between the two eyes; 3.4% of subjects with bilateral or unilateral visual field loss had more than four falls during the 2 years follow-up, compared with 0.55% of subjects without visual field loss.

In the Blue Mountains Eye Study,[15] 2,003 community dwellers aged 49 and older had reliable suprathreshold 76-point visual field tests and answered questions about falls within the 12 months before the vision examination. Instead of calculating binocular visual field loss, the Blue Mountains Eye Study evaluated visual field loss in the better eye, although the definition of visual field loss in the better eye was not included in the manuscript. There was a trend for increased odds of falling with greater visual field loss ($P = .02$). When visual field loss was treated as a continuous variable, there was no association with frequent falls per one SD change in the amount of visual field loss.[15] In the current study, binocular visual field loss was a significant risk factor for incident frequent falling in unadjusted and adjusted analyses using categorical and continuous variables. The prospective collection of the incident falls in the current study eliminates the temporal ambiguity of the association.

Another study that evaluated visual field loss and falls included 489 ambulatory adults aged 65 and older who received a comprehensive eye examination at a glaucoma consultation service.[25] After the eye examination, subjects answered questions over the telephone about the number of falls in the prior year that required medical attention or caused activity restrictions. The investigators reported that subjects with a 40% or greater loss in visual field were estimated to have three times the odds of falling as those with less than 5% visual field loss ($P = .06$). The types of visual field tests used in this study varied between participants. The formula used to calculate visual field loss weighted the better eye three times that of the worse eye and is not generally used by eye care providers, and there was no definition of the better eye in this study.

Although a large population-based sample of more than 4,000 community-dwelling women was studied in the current study, because participants were white women with relatively good health status, the results may not be generalizable to other demographic groups, including men, women of other racial groups, or individuals with poorer health or those residing in institutions. Another potential limitation of this study is that binocular visual field loss was calculated using Esterman's binocular visual field scoring algorithm rather than directly measuring the binocular visual field. Nevertheless, several studies have reported that results from calculated binocular visual fields are consistent with the results found when an Esterman binocular visual field test is performed.[35–38] The assessment of incident falls with 4-month follow-up postcards may not be optimal, because it may be subject to recall bias. In addition, inattention during visual field testing may be a cause of misclassification error, because participants who do not pay attention during the visual field test may miss more points. It was attempted to reduce this error by having the technicians monitor the women's fixation in addition to the automated monitoring performed by the machine. Although women who had unreliable tests with fixation losses of 33% or more were excluded, the rate of frequent falling was similar in women who had unreliable tests (16%) and those who had reliable tests. Thus, this bias was most likely nondifferential and biased the results to the null hypothesis.

The findings of the current study imply that interventions involving screening for and management of binocular vision field loss might have the potential for decreasing fall-related injuries. Although the risk factors for falls in older people are multifactorial, poor vision is an important contributing factor.[14] Little is known about which vision interventions reduce fall-related injuries.[39,40] The American Geriatrics Society identified the study of the relationship between treatment of visual problems, and falls prevention as a high priority of future research.[41] Because in SOF, 33.3% of frequent falls in women with severe binocular visual field loss were due to the severe binocular visual field loss, future research should focus on the potential benefits of screening for binocular visual field loss and the development of appropriate interventions such as mobility training that may prevent or decrease the risk of frequent falling.

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