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Dual visual impairment and contrast sensitivity among community-dwelling older adults: a cross-sectional study from the PrevQuedas Brazil trial

Duplo déficit visual e sensibilidade ao contraste em idosos da comunidade: estudo transversal do PrevQuedas Brasil

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Abstract

Objective: To investigate the importance of improving visual assessment for community-dwelling older adult fallers.

Methods: Cross-sectional study with eligible older adults (> 60 years old) living in the community and who suffered at least one fall in the last 12 months from the PrevQuedas Brasil clinical trial. Sociodemographic data, information on previous falls, physical and functional assessment (BOMFAQ and FES-I) were collected. We evaluated impairments in visual acuity and contrast sensitivity using the Snellen E chart and low-contrast visual acuity tests, respectively. Dual visual impairment refers to the presence of both impairments. For statistical analysis we compared the participants in relation to the number of falls (single fallers or recurrent fallers) using Chi-square or Fisher's exact test and the significance level was <0.05 for all analyses.

Results: Visual acuity, low contrast sensitivity, and dual visual impairment were associated with recurrent falls (OR 1.85); visual impairment was more prevalent among the oldest old. Approximately 90% of the participants reported using glasses, and 63.80% used multifocal lenses. Dual impairment was identified in 143 (20.30%) participants. In multivariate logistic regression, the predictive variables for recurrent falls were low contrast sensitivity (95%CI 1.15–2.47), dual visual impairment (95%CI 1.16–2.83), and self-perceived fall risk (95%CI 1.16–2.46) which was measured using the Falls Efficacy Scale-International.

Conclusion: Older adults with dual visual impairment are more likely to suffer recurrent falls. Low contrast sensitivity is crucial for fall risk assessment.

Trial registration: ClinicalTrials.gov (NCT01698580).

Keywords: aged; accidental falls; contrast sensitivity; visual acuity; risk factors.

Resumo

Objetivo: Este estudo investiga a importância de avaliar a visão de idosos caídores na comunidade.

Metodologia: Estudo transversal com idosos elegíveis (> 60 anos) residentes na comunidade e que sofreram pelo menos uma queda nos últimos 12 meses do ensaio clínico PrevQuedas Brasil. Foram coletados dados sociodemográficos, informações sobre quedas pregressas, exames físicos e funcionais (BOMFAQ e FES-I). Avaliamos os comprometimentos da acuidade visual e da sensibilidade ao contraste por meio da Tabela E de Snellen e testes de acuidade visual de baixo contraste, respectivamente. O duplo déficit visual refere-se à presença de ambas as deficiências. Para análise estatística comparamos os idosos com relação ao número de quedas (caídores únicos ou caídores recorrentes) usando Qui-quadrado ou Teste exato de Fisher e o nível de significância foi <0.05 para todas as análises.

Resultados: Baixa acuidade visual, baixa sensibilidade ao contraste e duplo déficit visual foram associados a quedas recorrentes com *odds ratio* — OR 1,85, frequentemente mais prevalente entre os idosos longevos. Cerca de 90,00% dos idosos relataram usar óculos e 63,80% usavam lentes multifocais. O duplo déficit visual foi identificado em 143 (20,30%) participantes. Nos modelos de regressão logística multivariados, verificamos que as variáveis preditoras para queda recorrente foram a baixa sensibilidade ao contraste (intervalo de confiança — IC95% 1,15–2,47), duplo déficit (IC95% 1,16–2,83) e a autopercepção do risco de cair (IC95% 1,16–2,46) medido pela *Falls Efficacy Scale-International*.

Conclusão: Idosos com baixa sensibilidade ao contraste e duplo déficit visual têm maiores chances de sofrerem múltiplas quedas quando comparados com idosos que possuem apenas baixa acuidade visual. Assim, a baixa sensibilidade ao contraste é essencial na avaliação do risco de quedas dos idosos.

Registro de estudo: ClinicalTrials.gov (NCT01698580).

Palavras-chave: idosos; acidentes por quedas; sensibilidades de contraste; fatores de riscos.



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INTRODUCTION

Visual impairment related to physiological aging or eye diseases is a critical risk factor for falls and hip fractures in community-dwelling older adults.¹ Overall, poor visual acuity and contrast sensitivity approximately double the fall risk, which can be increased by other biological factors.²⁻⁴ Falls can result in serious complications, such as fractures, dislocations, and traumatic brain injuries. In addition to the impact on individuals and families, these consequences are costly for the health care system.^{5,6}

Vision, a sensory system that detects environmental risks, is associated with postural strategies to maintain balance and gait.⁷ Disease-related vision changes (cataracts, glaucoma), low visual acuity, contrast sensitivity, and spatial perception, and decreased ability to detect hazards and assess distances are the main visual risk factors for falls. While visual acuity measurement consists of identifying details, contrast sensitivity testing seeks to assess everyday vision. Therefore, a combination of visual acuity and contrast sensitivity is considered important for real-life activities.⁷

In addition to visual impairment, there is also evidence that using multifocal lenses doubles the fall risk.⁸ The lower field of the lenses affects contrast sensitivity and depth perception, making it difficult to capture information from the environment, which could result in stumbling and tripping.⁹ Poorly lit environments and poor night vision also reduce contrast sensitivity, making it challenging to detect environmental hazards.¹⁰ Although visual impairment is correlated with falls, guidelines provide few management recommendations since scientific evidence about the effectiveness of visual assessments and interventions is limited. A randomized clinical trial¹¹ found that some visual interventions and recommendations increased the fall risk in frail older adults. However, only cataract surgery was found to be an effective intervention for improving visual function and reducing the fall and fracture rates.^{11,12} Since sensory information is vital for triggering balance strategies, investigating visual impairment should be mandatory in fall prevention efforts.¹⁰

Recently, the U.S. Preventive Services Task Force found insufficient information to recommend visual acuity screening for asymptomatic adults aged ≥ 65 years in primary care settings. However, based on the literature, it is reasonable to assume that the older population could benefit from a proper eye examination and early detection of vision impairment beyond visual acuity.^{13,14}

We sought to investigate the association between dual visual impairment (visual acuity and contrast sensitivity) with single and recurrent falls among older adults referred to a fall prevention program.¹⁵

METHODS

This cross-sectional study was conducted according to STROBE guidelines¹⁶ using secondary data from PrevQuedas Brazil, a multicenter, multifactorial, and interdisciplinary clinical trial to identify the effectiveness of a fall prevention program.¹⁷ We included community-dwelling older adults (> 60 years of age) who suffered at least 1 fall in the last 12 months. We excluded individuals with clinical conditions that precluded exercise interventions. Detailed exclusion criteria and sample size calculation methods have been described elsewhere.¹⁷ Data were collected between January 2013 and December 2019, and all participants provided written informed consent. This study was approved by the Ethics Committee of the University of São Paulo School of Medicine (protocol CAPPesq 0145/11). Participants were evaluated using a multidimensional questionnaire and underwent clinical and functional tests to identify fall risk factors.

The number of fall events was determined by self-report. A fall was defined as “an unexpected event in which the participants come to rest on the ground, floor, or a lower level.” Participants were asked to answer the question: “In the past 12 months, have you had any fall, including a slip or trip, in which you lost your balance and landed on the floor, ground, or a lower level?”¹⁸ Participants who reported one such event in the previous year were considered single fallers, while those who reported 2 or more were considered recurrent fallers. Injurious falls and the location of fall events (indoors or outdoors) were also investigated.

Dual visual impairment was identified through visual acuity and contrast sensitivity tests. Visual acuity was tested with the Snellen E chart at a distance of 5 meters. We considered values ≤ 0.50 as low visual acuity. Acuity was measured binocularly with best correction.¹⁹ Low contrast sensitivity was evaluated using a low contrast (10.00%) chart with letters similar to the Snellen E Chart at a distance of 3 meters. Participants could wear their normal distance vision glasses and were asked to read out the letters; those who could not read line 16 (the third line from the top) were considered impaired.²⁰

Previous eye disorders (cataract, macular degeneration, glaucoma), unoperated cataract, the number of visits to the ophthalmologist in the last year, and type of glasses (monofocal, multifocal) were investigated by self-report.

Sex, age group (60–69; 70–79; ≥ 80 years), including the oldest old group (≥ 80 years of age) were determined by self-report, in addition to marital status; race, and education level (basic literacy: ability to read, full literacy: ability to read and interpret).

The Brazilian Multidimensional Functional Assessment Questionnaire, which is based on the Older Americans Resources and Services scale, was used to identify disability in basic (BADL) and instrumental (IADL) activities of daily living. This questionnaire has been used in cross-sectional studies with older adults in São Paulo. The questionnaire contains 15 activities of daily living (8 BADL and 7 IADL) and asks participants if they have difficulty performing them (yes/no). The number of activities performed with difficulty was summed (0–15). Participants who reported difficulty with ≥ 5 activities were considered to have poor overall functional ability.²¹ Participants who reported difficulty with ≥ 3 BADL or IADL were considered to have a disability in basic and instrumental activities.²² We also asked participants if they used walking aids, which was considered indicative of limited mobility.

The Falls Efficacy Scale-International (FES-I) was used to assess participant concern about falling. This scale, adapted from Prevention of Falls Network Europe, assesses fall-related self-efficacy, ie, the degree of concern a person has about performing 16 activities without falling (activities of daily living, outdoor activities, and social participation). Scores range from 16 to 64 points, with higher scores indicating greater concern about falling (a high perceived risk). Thus, participants scoring between 16 and 22 points were

considered to have a low perceived risk of falling and those scoring ≥ 23 points to have a high perceived risk.²³

Data analysis was performed by comparing single fallers and recurrent fallers in relation to the variables of interest. The number of falls was compared to the variables of interest using the chi-square test or Fisher's exact test. Multivariate regression was used to identify the association between visual impairment and single and recurrent fallers. Variables whose association with the dependent variable was $p < 0.20$ in the univariate models were selected for the initial multivariate model. Variables that did not reach $p < 0.05$ were excluded in a backward stepwise method. The data were analyzed using IBM SPSS Statistics 23.0. A significance level of < 0.05 was used for all statistical tests.

RESULTS

Of the total sample of 703 older adults, 650 (92.40%) had some type of visual deficit (visual acuity, low contrast sensitivity, or dual visual impairment). There was a higher prevalence of low contrast sensitivity among those > 80 years of age (48.30%). Of the 602 women, 72.00% had some type of visual impairment (low visual acuity or low contrast sensitivity) (Table 1). The sample was classified into 3 groups: low visual acuity, low contrast sensitivity, and dual visual impairment (Figure 1).

TABLE 1. Sociodemographic characteristics of the participants (n = 703).

Variables	No impairment n = 53 (7.50)	Low contrast n = 233 (33.10)	Visual acuity n = 274 (38.90)	Dual deficit n = 143 (20.30)	N total (%) 703 (100)	p-value
Age, n (%)						
< 80 years	37 (6.70)	160 (20.00)	242 (48.30)	113 (20.50)	552 (78.05)	0.000
> 80 years	16 (10.60)	73 (48.30)	32 (21.20)	30 (19.90)	151 (21.50)	
Age group, n (%)						
60–69 years	15 (6.40)	38 (16.30)	136 (58.40)	44 (18.80)	233 (33.10)	0.000
70–79 years	22 (6.90)	122 (38.20)	106 (33.20)	69 (21.60)	319 (45.40)	
≥ 80 years	16 (10.60)	73 (48.30)	32 (21.20)	30 (19.90)	151 (21.50)	
Sex, n (%)						
Male	9 (8.90)	33 (32.70)	39 (38.60)	20 (19.80)	101 (14.40)	0.956
Female	44 (7.30)	200 (33.20)	235 (39.00)	123 (20.40)	602 (85.60)	
Marital status, n (%)						
Widowed	19 (7.90)	92 (38.30)	76 (31.70)	53 (22.10)	240 (34.10)	0.214
Married	18 (6.90)	80 (30.80)	112 (43.10)	50 (19.20)	260 (37.00)	
Divorced	7 (8.40)	24 (28.90)	40 (48.20)	12 (14.50)	83 (11.80)	
Single	9 (7.50)	37 (30.80)	46 (38.30)	28 (23.30)	120 (17.10)	

Continue...

TABLE 1. Continuation.

Variables	No impairment n = 53 (7.50)	Low contrast n = 233 (33.10)	Visual acuity n = 274 (38.90)	Dual deficit n = 143 (20.30)	N total (%) 703 (100)	p-value
Race, n (%)						
White	36 (8.70)	142 (34.10)	155 (37.30)	83 (20.00)	416 (59.20)	0.796
Black	4 (6.00)	24 (35.80)	22 (32.80)	17 (25.40)	67 (9.50)	
Mixed	10 (6.60)	42 (27.80)	69 (45.70)	30 (19.90)	151 (21.50)	
Education status, n (%)						
Basic literacy	25 (9.30)	100 (37.30)	85 (31.70)	58 (21.60)	268 (38.10)	0.009
Full literacy	14 (4.20)	96 (29.70)	146 (45.20)	67 (20.70)	323 (45.90)	
Falls, n (%)						
1 fall	16 (7.00)	64 (28.10)	110 (48.20)	38 (16.70)	228 (32.50)	0.049
2 falls	14 (8.00)	60 (34.50)	62 (35.60)	38 (21.80)	174 (24.70)	
≥ 3 falls	23 (7.60)	109 (36.20)	102 (33.90)	67 (22.30)	301 (42.80)	

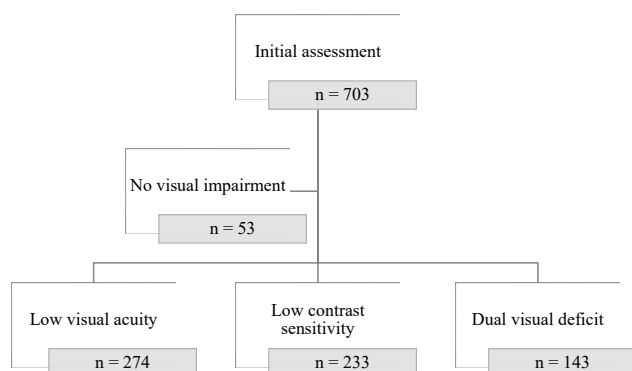


FIGURE 1. Flowchart.

In the univariate analysis (Table 2), the sample was divided into single and recurrent fallers and only participants with some type of visual impairment were included ($n = 650$). There was a high likelihood that participants with dual visual

impairment were recurrent fallers (OR 1.85; $p < 0.005$). Approximately 90.00% of the participants reported using glasses, and 63.80% used multifocal lenses. Dual visual impairment was identified in 143 (20.30%) participants. Of the 438 (67.30%) recurrent fallers with visual impairments, the falls of 312 (71.40%) occurred outdoors, and 303 (69.20%) suffered some injury when falling. Among the 414 (63.70%) participants concerned about falling again according to FES-I scores, the odds ratio of being a recurrent faller increased by 1.77. Being among the oldest old, having an unoperated cataract, recurrent falls, and walking aid use were associated with visual acuity impairment (Table 2).

In multivariate logistic regression, predictive variables for recurrent falling were visual deficit type (low contrast sensitivity [95%CI 1.15–2.47] and dual visual impairment [95%CI 1.16–2.83]) and self-perceived fall risk (95%CI 1.16–2.46) according to the FES-I (Table 3).

TABLE 2. Comparison of visual impairment among single and recurrent fallers according to sociodemographic, clinical, and functional variables ($n = 650$).

Variables	Recurrent falls (n = 650)		OR	95%CI	p-value
	Yes n = (%)	No n = (%)			
Visual deficit					
Snellen E chart	164 (37.40)	110 (51.90)	1.00		< 0.001
Low contrast sensitivity	169 (38.60)	64 (30.20)	1.77	1.22–2.58	
Dual deficit	105 (24.00)	38 (17.90)	1.85	1.19–2.89	
Age groups					
60–69 years	149 (34.00)	69 (32.50)	1.00		0.870
70–79 years	197 (45.00)	100 (47.20)	0.91	0.62–1.32	
≥ 80 years	92 (21.00)	43 (20.30)	0.99	0.62–1.57	

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TABLE 3. Continuation.

Variables	Recurrent falls (n = 650)		OR	95%CI	p-value
	Yes n = (%)	No n = (%)			
Oldest old					
< 80 years	346 (79.00)	169 (79.70)	1.00		
≥ 80 years	92 (21.00)	43 (20.30)	1.04	0.69–1.56	0.459*
Sex					
Male	55 (12.60)	37 (17.50)	1.00		
Female	383 (87.40)	175 (82.50)	1.47	0.93–2.31	0.061*
Unoperated cataract	109 (24.90)	44 (20.80)	1.26	0.85–1.88	0.143*
Glaucoma	50 (11.40)	16 (7.50)	1.57	0.87–2.84	0.080*
Macular degeneration	13 (3.00)	6 (2.80)	1.05	0.39–2.80	0.570*
Ophthalmologist visit in the last year (no)	266 (60.70)	119 (56.10)	0.82	0.59–1.53	0.151*
Lens type					
Monofocal	141 (34.60)	77 (40.30)	1.00		
Multifocal	267 (65.40)	114 (59.70)	1.27	0.89–1.82	0.102*
Fall with injury	303 (69.20)	143 (67.50)	1.08	0.76–1.53	0.360*
Fall location					
Indoors	125 (28.60)	48 (22.60)	1.00		
Outdoors	312 (71.40)	164 (77.40)	0.71	0.51–0.99	0.064*
Fear of falling	352 (80.40)	156 (73.60)			0.032*
Disability in BADL					
0–2 activities	239 (54.60)	134 (63.30)	1.00		
≥ 3 activities	199 (45.40)	78 (36.80)	1.43	1.02–2.00	0.022*
Disability in IADL					
0–2 activities	219 (50.00)	130 (61.30)	1.00		
≥ 3 activities	219 (50.00)	82 (38.70)	1.58	1.13–2.21	0.004*
Use of walking aids, n (%)	63 (14.40)	24 (11.30)			0.171*
Perceived fall risk (FES-I)					
Low (16–22 points)	92 (21.00)	68 (32.10)	1.00		
High (≥ 23 points)	346 (79.00)	68 (32.10)	1.77	1.22–2.56	0.002*

Pearson chi-square/*Fisher's exact test. BADL: Basic Activities of Daily Living; FES-I: Falls Efficacy Scale-International; IADL: Instrumental Activities of Daily Living; Snellen E chart: score ≤ 0.5; Low contrast sensitivity: unable to read at least line 16 in the low contrast sensitivity E chart (10%); Dual visual deficit: combination of low visual acuity (Snellen) and low contrast sensitivity.

TABLE 3. Multivariate analysis to identify associations with the number of falls. (n = 650).

Variables	Initial model				Final model			
	OR	95%CI		p-value	OR	95%CI		p-value
Visual impairment: Snellen				0.27				
Low contrast sensitivity	1.618	1.069	2.450	0.230	1.693	1.159	2.473	0.006
Dual deficit	1.690	1.052	2.716	0.030	1.813	1.161	2.831	0.009
Sex, male vs female	1.479	0.900	2.430	0.123				
Unoperated cataract, no vs yes	1.240	0.796	1.932	0.342				
Glaucoma, no vs yes	1.383	0.739	2.587	0.310				
Macular degeneration, no vs yes	1.466	0.495	4.340	0.490				
Lens type, monofocal vs multifocal	1.212	0.839	1.751	0.305				
Fear of falling (no vs yes)	1.060	0.667	1.683	0.806				
Fall location, indoor vs outdoor	0.735	0.486	1.113	0.146				
Disability in IADL, 0-2 activities vs ≥ 3 activities	1.250	0.807	1.936	0.317				
Disability in BADL, 0-2 activities vs ≥ 3 activities	1.127	0.734	1.730	0.586				
Use of walking aids, no vs yes	1.052	0.597	1.855	0.860				
Perceived of risk of falling (FES-I), low (16-22 points) vs high (≥ 23 points)	1.324	0.837	2.094	0.230	1.695	1.167	2.462	0.006

DISCUSSION

Since the relationship between low visual acuity (Snellen chart) and a higher risk of falls and recurrent falls among community-dwelling older adults is already well established in the literature,^{1,9,12,14} we used low visual acuity as a reference for comparison with low contrast sensitivity (quick method) and dual visual impairment. According to our results, older people with low visual acuity, low contrast sensitivity, or both were frequently older, had an unoperated cataract, were recurrent fallers, and used walking aids. In addition to these characteristics, those with low contrast sensitivity, either as a single condition or in combination with low visual acuity, more frequently reported not visiting an ophthalmologist in the last year, disability in activities of daily living, and a high perceived risk of falling. Glaucoma was more frequent among participants with low contrast sensitivity alone. Impaired visual acuity, low contrast sensitivity, or a combination of both increased the likelihood of recurrent falls.

Several studies have demonstrated the association between impaired visual acuity and low contrast sensitivity and recurrent falls.^{2,24} However, our study is the first to identify an association with dual visual impairment. Since both impaired visual acuity and low contrast sensitivity were associated with recurrent falls, dual visual impairment was also expected to be associated with recurrent falls. Surprisingly, we found a high fall risk for low contrast sensitivity and dual impairments. In fact, the odds of falling among those with low contrast sensitivity alone or dual visual impairment were higher than low visual acuity alone. This indicates:

1. The importance of low contrast sensitivity testing among older adults who have fallen at least once in the previous year and
2. Assessing visual acuity alone in this population is insufficient. Furthermore, longitudinal studies have shown that poor vision precedes falls, which highlights the need to intervene as early as possible.¹

Coleman et al. investigated the association between visual impairment and recurrent falls in 6330 community-dwelling older women,²⁵ finding that those with low contrast sensitivity and low depth perception had a high risk of hip fracture, which suggests that testing and intervention should be prioritized to reduce fall risk and fall injuries.

A large proportion of our participants used multifocal lenses and had fallen outdoors. Multifocal lenses increase the risk of falls among older adults because they impair contrast sensitivity and depth perception, although we found no association between number of falls (single or recurrent) and lens type, principally because low contrast sensitivity is not

improved by glasses. Lord et al. found that 56.00% of older adults who used multifocal lenses had worse depth perception and a greater likelihood of falling (RR 1.31; SD 0.89–1.92), especially in outdoor environments (RR 1.62; SD 0.98–2.67).⁸

Recurrent falls were associated with overall disability (BADL and IADL) and a high perceived fall risk (FES-I), but did not affect the response to the question “Do you fear falling again?” In the multivariate analysis, the FES-I results differed from self-reported fear of falling. This can be explained by the fact that self-reports are inaccurate and involve perception bias about actual and expected behavior. As an indirect means of assessing the fear of falling, self-efficacy refers to an individual’s perceived abilities (confidence) in daily activities, and fear of falling is indirectly labeled ‘low self-efficacy.’ Our analysis showed a 69.00% higher chance of recurrent falls among those with low self-efficacy.²⁶ Visual impairment commonly restricts the activities of older adults, since visual impairment, especially when added to personal and environmental limitations, contributes to functional decline and, consequently, hinders performance of activities of daily living.^{27,28} Lord & Dayhew¹² suggest that low-contrast visual acuity tests better reflect the visual requirements of everyday situations.

The frequency of visual impairment and the risk of falls were higher among participants who used walking aids. Mobility problems in this population have various causes and are likely multifactorial in nature. The population-based Beaver Dam Eye Study investigated the association between performance-based measures of visual functioning and the occurrence of falls, finding a 3.60% incidence of walking aid use, which was associated with visual sensitivity (OR 3.51; 95%CI 1.72–7.18).²⁹

Our results have certain implications. First, a systematic review³⁰ of 10 studies in developed countries found that visual self-assessment and tests, such as visual acuity, are ineffective in detecting disabling visual impairments in older adults. Referral to specialized services (secondary care) tends to occur only for more severe surgical conditions. There is also low adherence to referrals by general practitioners, and a lack of evidence regarding causation. The authors suggested that poor adherence to ophthalmological guidelines might be related to the costs of subsequent examination and eyeglasses, the inability of ophthalmological services to absorb the demand for elective cataract surgery, and poor understanding of patient complaints about visual difficulties, since they can be wrongly considered part of the physiological aging process.

Second, particularly in Brazil, referrals to an ophthalmologist (secondary care level) are made through primary care in the health services network. Thus, consultation with

an ophthalmologist depends on screening for visual impairments, the availability of eye care services and trained professionals, and health empowerment. According to data from the Brazilian Council of Ophthalmology,³¹ in 2018 10 289 341 ophthalmological consultations were performed through the Unified Health System, of which 3 732 024 occurred in São Paulo. In this state, the ratio of ophthalmologists to inhabitants is 1:7000. Although this proportion varies in other states, most are adequate according to World Health Organization recommendations (1: 30 000). Thus, referrals for eye care must be encouraged when visual impairment is detected in screening. Systematic contrast sensitivity screening, particularly in older adults who have fallen in the last 12 months, is important, since it is key to linking patients to vision care. The first step toward this goal is to expand the awareness of health care professionals about fall prevention.

Limitations

Given that this is a cross sectional study, causal effects cannot be determined. Our external validity is limited since the sample consisted of participants eligible for a clinical trial, the majority of whom were women. Furthermore, participants were assessed by a multidisciplinary care team that is generally available only in tertiary care services.

Highlights

- Low contrast and dual visual impairment (low visual acuity and low contrast sensitivity) were associated with recurrent falls.
- Multidimensional assessment of older adults, including contrast sensitivity testing, may increase the odds of identifying older adults at risk of recurrent falls

CONCLUSION

Older people with dual visual impairment are more likely to have suffered recurrent falls. In particular, low contrast sensitivity is crucial for fall risk assessment. Strengthening visual screening and referral to appropriate eye care services should be included in fall prevention efforts.

Conflict of interest

The authors declare no conflicts of interest.

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Author contributions

FPCF: conceptualization, data curation, investigation, methodology, visualization, writing – original draft, writing – review & editing. MAZM: conceptualization, data curation, investigation, methodology, visualization, writing – original draft, writing – review & editing. RRV: conceptualization, data curation, investigation, methodology, visualization, writing – original draft, writing – review & editing. EYI: conceptualization, data curation, investigation, methodology, visualization, writing – original draft, writing – review & editing. ASP: formal analysis, investigation, methodology. AS: formal analysis, investigation, methodology. MRP: conceptualization, methodology, project administration, supervision, writing – review & editing.

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