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Relationship between fear of falling and mobility varies with visual function among older adults

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Aim: The present study examined the association between vision, fear of falling and fear-related activity restriction, and assessed the effect of vision on the relationship between fear of falling and mobility, using data from a nationally representative sample of community-dwelling adults aged ≥50 years.

Methods: Participants (n = 5003) completed an interview and health assessment (including Timed Up-and-Go, vision and cognitive tests). Visual acuity and contrast sensitivity were assessed using an Early Treatment Diabetic Retinopathy Study logMAR chart and Functional Vision Analyzer, respectively. Participants self-reported their vision as excellent, very good, good, fair or poor. They were assigned to no fear of falling, fear without activity restriction and fear with activity restriction groups. Logistic regression models examined the relationship between vision, fear of falling and activity restriction. Linear regression models were used to examine the main and interaction effects of fear of falling, self-reported vision, visual acuity, and contrast sensitivity on mobility after adjusting for confounders.

Results:Poorer self-reported vision was independently associated with fear of falling and fear-related activity restriction (P < 0.05), but visual acuity and contrast sensitivity were not. Participants with the lowest visual acuity and contrast sensitivity levels, combined with fear-related activity restriction, had slower Timed Up-and-Go than those in the highest visual performance quartiles (P < 0.05).

Conclusions: Participants’ perceptions of visual function were related to fear of falling and activity restriction, but this was not explained by other visual factors measured here. However, poorer visual acuity and contrast sensitivity did moderate the relationship between fear-related activity restriction and mobility, highlighting the importance of a comprehensive vision assessment especially in individuals with fear of falling. Geriatr Gerontol Int 2013; ••:

Introduction

Fear of falling (FOF) has been defined as “a lasting concern about falling that leads to an individual avoiding activities that he/she remains capable of performing”.1 It affects up to 30% of community-dwelling older adults,2,3 and occurs in those with and without a history of falls. It is more common in females, and is independently associated with previous falls, depression, poor self-reported health, reduced social activity and impaired mobility.4-8 The consequences of fear-related activity restriction include a decline in physical and social function, which can increase the risk of mobility decline, falls and functional disability.9,10

Visual impairment can include deficits in visual acuity (VA), contrast sensitivity (CS), visual field (VF) and depth perception (DP). Lower VA, CS and VF have been associated with poorer mobility in community-dwelling adults,11-16 whereas deficits in VA, CS, VF and DP have been associated with falls, especially recurrent falls.17-21

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Estimates of the effect of vision on FOF and activity restriction have been mixed. No independent relationship between self-reported visual impairment and FOF or associated activity restriction was seen in community representative samples; however, moderate and severe self-reported visual impairments were independently associated with FOF-related activity restriction among community-dwelling older adults in receipt of home care services. Deshpande et al. found that psychophysiologically measured visual function, specifically CS and VA, was not linked to FOF; however, reduced CS was associated with FOF-related activity restriction among those without depressive symptoms. Finally, longitudinal studies have shown that reduced VA predicts the development of FOF and mobility impairment after 5 years.

Currently, studies examining associations between FOF, vision and mobility are limited. Both FOF and poor vision have been associated with impaired mobility, but it is unclear how visual impairment and FOF interact with respect to mobility impairment, and if so, which components of vision are most important. Understanding this would allow specific groups to be identified and targeted for assessment and intervention. Therefore, the aims of the present study were first, to examine the role of vision (self-reported vision, VA and CS) in FOF and FOF-related activity restriction, and second, to examine the influence of vision in the relationship between FOF and mobility, using data from a nationally representative sample of community-dwelling adults aged 50 years and older.

Methods

Study design

The Irish Longitudinal Study on Aging (TILDA) is a prospective cohort study of the social, economic and health circumstances of community-dwelling older adults in Ireland. Analysis is based on the first wave of data, collected between October 2009 and July 2011. The sampling frame is the Irish Geodirectory, a listing of all residential addresses in the Republic of Ireland. A clustered sample of addresses was chosen, and household residents aged ≥50 years and their spouses/partners (of any age) were eligible to participate. Ethical approval was obtained from the Trinity College Dublin Research Ethics Committee, and participants provided written informed consent.

The study design is described elsewhere. Briefly, data collection included: (i) a computer-assisted personal interview that included detailed questions on sociodemographics, wealth, health, lifestyle, social support and participation, use of health and social care, and attitudes to aging; (ii) a self-completion questionnaire; and (iii) a detailed health assessment carried out by research nurses including cognitive, cardiovascular, mobility, strength, bone and vision tests. In total, 8175 individuals aged ≥50 years were interviewed, of whom 5037 attended the health center assessment (61.3%). Inclusion criteria for this analysis was a Mini-Mental State Examination (MMSE) score ≥18, no history of Parkinson’s disease, Alzheimer’s disease or dementia, participation in a health center assessment, and completion of the FOF and activity restriction questions in the interview (n = 5003).

Outcome measures

Demographics and health

Age, sex and highest level of education attained were recorded. Primary, secondary and tertiary education corresponded to ≤8, 9–13 and ≥13 years of education, respectively. Height and weight were measured, and body mass index (BMI) was calculated. Participants self-reported doctor-diagnosed chronic conditions from the following: heart attack or heart failure or angina, stroke, diabetes, chronic lung disease, asthma, arthritis, osteoporosis, cancer, peptic ulcer, hip fracture, hypertension and high cholesterol. The number of medications was also recorded. Depressive symptoms were assessed using the 20-item Center for Epidemiological Studies Depression (CES-D) scale, where a score of ≥16 represents clinically relevant depressive symptoms.

Fear of falling and falls

Fear of falling was assessed with the question “Are you afraid of falling?”. Those that answered “Yes” were asked “Do you ever limit your activities, for example, what you do or where you go, because you are afraid of falling?”. It should be noted that this latter question might combine both physical and social activity limitations. Similar questions have been used in previous studies and allowed participants to be classified into three groups: (i) no FOF; (ii) FOF, but no activity restrictions (FOF-NAR); and (iii) FOF with activity restrictions (FOF-AR). Participants were also asked how many times they had fallen in the previous year.

Cognitive function

Participants completed the MMSE, which assesses global cognition (maximum score 30). A letter fluency task (list as many words as possible beginning with “F” in 1 min) measured expressive language and executive function, and a computer-based choice reaction time test measured processing speed. In this test, participants depressed a button, released it in response to an on-screen stimulus and pressed the appropriate target button (this occurred approximately 100 times). The
mean time from appearance of the stimulus to pressing
this button was the choice reaction time. Both verbal
fluency and choice reaction time have been shown to be
independent predictors of Timed Up-and-Go (TUG)
performance.33

Physical function

Maximum grip strength was the highest score from two
tests on each hand using a Baseline hydraulic hand
dynamometer (Fabrication Enterprises, White Plains,
NY, USA). Grip strength declines with age and indicates
overall strength.34 Mobility was assessed with the TUG
test using a chair with armrests and seat height of
46 cm. Participants were asked to rise from the chair,
walk 3 m at normal pace, turn around, walk back and sit
down again.35 Walking aids were allowed, and no
instructions were given about the use of participants’
arms. The time taken from the command “Go” to when
the participant sat with their back resting against the
back of the chair was recorded using a stopwatch.

Vision

Participants self-reported their vision as excellent, very
good, good, fair or poor;36 one participant reported
being registered blind and was added to the poor vision
group. A history of cataracts and related surgery, glau-
coma and age related macular degeneration (ARMD)
was also recorded.

VA represents a high contrast letter recognition task,
and was assessed using an Early Treatment Diabetic
Retinopathy Study (ETDRS) logMAR chart (Precision
Vision, La Salle, IL, USA) at a viewing distance of
4 m.37,38 VA was measured psychophysically for both
eyes, using the habitual distance vision correction if
required. For statistical purposes, the best acuity value
measured from either eye was selected and converted
to a Visual Acuity Score (VAS).39 This score inverts
the logMAR scale using the formula: VAS = 100 –
50 × logMAR, so that a VAS of 100 represents a
logMAR score of 0 or 20/20 vision. For each letter that
is read correctly using the ETDRS chart, there is a
corresponding 1-point increase in the VAS. This allows
a more intuitive interpretation of the acuity scores, as
higher values indicate better acuity. The VAS was sub-
sequently expressed in quartiles and deciles.

CS represents the ability to distinguish an object from
the background in varying size and contrast conditions.
It was measured in the eye with better VA using a
Functional Vision Analyser (Stereo Optical, Chicago,
IL, USA) under mesopic (3 cd/m²) background illumina-
tion conditions. Testing was then repeated for the
same background illumination conditions, but in
the presence of a radial glare source.39 During the test,
the respondent viewed a Functional Acuity Contrast
Test (FACT), which comprised sinusoidal gratings pre-
sented as Gabor patches at five spatial frequencies of
1.5, 3, 6, 12 and 18 cycles per degree (cpd) respectively.
For each spatial frequency, a series of nine patches were
presented in order of decreasing contrast (0.15 log unit
or 50% loss of contrast between consecutive patches).
Respondents were instructed to indicate if the gratings
tilted to the left (+15°), right (−15°) or upright (0°),
moving from patch 1 to 9 for each spatial frequency
tested, in order of increasing frequency. The CS score
corresponds to the contrast of the last grating that was
accurately identified on each row.

Factor analysis was used to reduce the dimension of
the 10 CS scores (each of five frequencies in two glare
conditions). As the CS variables are based on ordinal
scores, factor analysis using a polychoric correlation
matrix was carried out. Two factors were identified and
retained based on their eigenvalues and amount of vari-
ance explained (69.2% in total). Oblique rotation using
the direct oblimin criterion suggested two factors cor-
responding to the contrast sensitivity at high spatial
frequencies (6, 12, 18 cpd) and low spatial frequencies
(1.5, 3, 6 cpd). CS at the middle spatial frequency
(6 cpd) loaded onto both factors (Table 1). No factor
separated the glare from the “no glare” condition. Two
factor scores were derived for each individual corre-
sponding to their “high frequency” and “low frequency”
CS. Each factor score was divided into quartiles and
deciles for use as independent variables in regression
analyses.

Statistical analysis

Statistical tests were carried out using Stata v12
(StataCorp LP, College Station, TX, USA). All analyses
were weighted with respect to age, sex and education to
the Quarterly National Household Survey (2010) to
eNSure that data were nationally representative. Data
were further weighted by health status (self-reported
health, disability status) and sociodemographic factors
(age, education) to account for those who did not attend
a health assessment. Baseline characteristics of each
group were compared using regression analysis and
χ²-tests.

Logistic regression analysis was used to examine the
relationship of vision with FOF and FOF-related activity
restriction. VA, CS factors 1 and 2 (all expressed as
deciles), and self-reported vision were entered into sepa-
rate models, which also included the effects of age, sex
and education.

Linear regression was then used to examine the asso-
ciations between FOF groups and TUG before and after
adjusting for age, sex, education, BMI, chronic condi-
tions, medications, history of falls in the previous year,
CES-D score, letter fluency, choice reaction time,
maximum grip strength and doctor-diagnosed cataracts

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Results

Baseline characteristics of the no FOF (n = 3974), FOF-
NAR (n = 727) and FOF-AR (n = 302) groups are pro-
vided in Table 2. Both FOF groups had more
participants aged ≥75 years, were more likely to be
female, have greater comorbidities and poorer physical
health, mental health, cognitive function, and visual
function than the no FOF group (P < 0.001). Most pro-
nounced differences were observed in the FOF-AR
group.

Psychophysical measures of vision (deciles of VA and
CS) were not associated with FOF after adjusting for
age, sex and education (P > 0.05; Fig. 1). However, there
was a statistically significant worsening of FOF with
poorer self-reported vision. This was particularly
marked among those who rated their vision as “fair”
or “poor” (P < 0.05). An identical relationship was
observed for FOF-related activity restriction.

Both FOF groups had slower TUG times than the
no FOF group in univariate and multivariate analysis
(P < 0.001; models 1 and 2, Table 3). The exponent of
additive coefficients for log(TUG) can be interpreted as
multiplicative coefficients for TUG, and so the coeffi-
cients in Table 3 correspond to those in the FOF-NAR
group completing TUG 3.8% more slowly than those
without FOF, whereas those with FOF-related activity
restriction completed TUG 13.7% more slowly.

Poorer self-reported vision was independently associ-
ated with slower TUG after adjusting for all covariates
(P < 0.05), whereas VA and CS had no independent
effect on TUG performance (results not shown). Similar
effects were observed when all psychophysical and self-
reported vision variables were entered simultaneously
(model 3, Table 3). However, adjusting for these vision
variables had little effect on the FOF coefficients, and
therefore did not explain the relationship between FOF,
activity restriction and mobility.

Interaction effects for FOF with VA, high frequency
and low frequency CS were statistically significant in the
FOF-AR group (P < 0.001), but interaction effects with
self-reported vision were not (Fig. 2). Specifically, mar-
ginal interaction plots adjusting for covariates show that
individuals with FOF-related activity restriction who
were in the lowest quartile of VA and CS had slower
TUG than those in the highest quartiles (P < 0.05).

Table 1  Rotated factor loadings and unique variance for each contrast
sensitivity variable

<table>
<thead>
<tr>
<th></th>
<th>Factor 1 (high spatial frequencies)</th>
<th>Factor 2 (low spatial frequencies)</th>
<th>Unique variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS (no glare)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5 cpd</td>
<td>−0.155</td>
<td>0.7598</td>
<td>0.5312</td>
</tr>
<tr>
<td>3 cpd</td>
<td>0.088</td>
<td>0.7823</td>
<td>0.3029</td>
</tr>
<tr>
<td>6 cpd</td>
<td>0.4526</td>
<td>0.472</td>
<td>0.3324</td>
</tr>
<tr>
<td>12 cpd</td>
<td>0.839</td>
<td>0.0079</td>
<td>0.2885</td>
</tr>
<tr>
<td>18 cpd</td>
<td>0.6489</td>
<td>−0.1213</td>
<td>0.6526</td>
</tr>
<tr>
<td>CS (glare)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5 cpd</td>
<td>−0.0798</td>
<td>0.78</td>
<td>0.4551</td>
</tr>
<tr>
<td>3 cpd</td>
<td>0.1751</td>
<td>0.7176</td>
<td>0.3133</td>
</tr>
<tr>
<td>6 cpd</td>
<td>0.5783</td>
<td>0.3742</td>
<td>0.2825</td>
</tr>
<tr>
<td>12 cpd</td>
<td>0.8757</td>
<td>−0.0286</td>
<td>0.2604</td>
</tr>
<tr>
<td>18 cpd</td>
<td>0.6793</td>
<td>0.025</td>
<td>0.5189</td>
</tr>
</tbody>
</table>

High loadings (≥0.3) are shown in bold. cpd, cycles per degree; CS, contrast sensitivity.
### Fear of falling, vision and mobility

**Table 2** Baseline characteristics of no fear of falling, fear of falling with activity restriction and fear of falling with no activity restriction groups

<table>
<thead>
<tr>
<th></th>
<th>no FOF (n = 3974)</th>
<th>FOF-NAR (n = 727)</th>
<th>FOF-AR (n = 302)</th>
<th>Total (n = 5003)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50–64</td>
<td>2657 (64.1)</td>
<td>396 (46.9)</td>
<td>159 (43.8)</td>
<td>3212 (59.8)</td>
</tr>
<tr>
<td>65–74</td>
<td>1016 (22.8)</td>
<td>217 (23.4)***</td>
<td>98 (25.6)***</td>
<td>1331 (23.1)</td>
</tr>
<tr>
<td>≥75</td>
<td>301 (13.1)</td>
<td>114 (29.7)</td>
<td>45 (30.6)</td>
<td>460 (17.1)</td>
</tr>
<tr>
<td><strong>Sex (female)</strong></td>
<td>1938 (45.3)</td>
<td>557 (76.1)***</td>
<td>218 (71.4)***</td>
<td>2713 (52.2)</td>
</tr>
<tr>
<td><strong>Education (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>805 (33.7)</td>
<td>190 (45.9)</td>
<td>94 (51.9)</td>
<td>1089 (37.0)</td>
</tr>
<tr>
<td>Secondary</td>
<td>1675 (45.8)</td>
<td>300 (39.5)***</td>
<td>117 (35.5)***</td>
<td>2092 (44.0)</td>
</tr>
<tr>
<td>Tertiary</td>
<td>1492 (20.5)</td>
<td>237 (14.6)</td>
<td>91 (12.6)</td>
<td>1820 (19.0)</td>
</tr>
<tr>
<td><strong>BMI (kg/m²)</strong></td>
<td>28.54 ± 4.78</td>
<td>29.10 ± 5.51*</td>
<td>29.49 ± 5.86*</td>
<td>28.70 ± 5.00</td>
</tr>
<tr>
<td><strong>Chronic conditions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 condition</td>
<td>1199 (29.4)</td>
<td>189 (23.9)</td>
<td>49 (13.6)</td>
<td>1437 (27.3)</td>
</tr>
<tr>
<td>2 conditions</td>
<td>881 (22.5)</td>
<td>192 (24.3)***</td>
<td>75 (21.1)***</td>
<td>1148 (22.7)</td>
</tr>
<tr>
<td>≥3 conditions</td>
<td>859 (23.4)</td>
<td>254 (36.6)</td>
<td>143 (56.0)</td>
<td>1236 (24.3)</td>
</tr>
<tr>
<td>Medications</td>
<td>1.23 ± 1.08</td>
<td>1.71 ± 1.04***</td>
<td>2.08 ± 1.01***</td>
<td>1.37 ± 1.10</td>
</tr>
<tr>
<td><strong>History of falls (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 fall</td>
<td>467 (11.8)</td>
<td>133 (16.8)</td>
<td>52 (18.2)</td>
<td>652 (13.1)</td>
</tr>
<tr>
<td>≥2 falls</td>
<td>205 (5.4)</td>
<td>86 (11.9)***</td>
<td>49 (14.3)***</td>
<td>340 (7.1)</td>
</tr>
<tr>
<td><strong>Depressive symptoms</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMSE</td>
<td>28.37 ± 1.87</td>
<td>28.13 ± 2.05</td>
<td>27.72 ± 1.99***</td>
<td>28.28 ± 1.92</td>
</tr>
<tr>
<td><strong>Letter fluency</strong></td>
<td>11.53 ± 5.00</td>
<td>10.62 ± 4.61***</td>
<td>10.79 ± 5.03*</td>
<td>11.33 ± 4.96</td>
</tr>
<tr>
<td><strong>Choice reaction time (ms)</strong></td>
<td>825 ± 280</td>
<td>907 ± 370***</td>
<td>935 ± 320***</td>
<td>846 ± 301</td>
</tr>
<tr>
<td><strong>TUG (s)</strong></td>
<td>8.58 ± 1.81</td>
<td>9.72 ± 2.57***</td>
<td>11.41 ± 5.05***</td>
<td>8.97 ± 2.46</td>
</tr>
<tr>
<td><strong>Cataracts – with surgery (%)</strong></td>
<td>160 (4.9)</td>
<td>53 (12.8)</td>
<td>28 (13.1)</td>
<td>241 (6.8)</td>
</tr>
<tr>
<td><strong>Cataracts – no surgery (%)</strong></td>
<td>126 (4.2)</td>
<td>48 (7.1)***</td>
<td>18 (7.1)***</td>
<td>192 (4.9)</td>
</tr>
<tr>
<td><strong>Glaucoma (%)</strong></td>
<td>71 (1.9)</td>
<td>21 (3.5)</td>
<td>13 (3.5)***</td>
<td>105 (2.4)</td>
</tr>
<tr>
<td><strong>ARM (%)</strong></td>
<td>57 (1.7)</td>
<td>22 (3.4)*</td>
<td>5 (1.2)</td>
<td>84 (2.0)</td>
</tr>
<tr>
<td><strong>Self-reported vision (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>894 (17.9)</td>
<td>121 (14.7)</td>
<td>48 (11.3)</td>
<td>1063 (18.2)</td>
</tr>
<tr>
<td>Very good</td>
<td>1522 (37.8)</td>
<td>287 (36.7)</td>
<td>100 (29.0)</td>
<td>1909 (37.0)</td>
</tr>
<tr>
<td>Good</td>
<td>1273 (33.4)</td>
<td>255 (36.3)</td>
<td>104 (35.5)***</td>
<td>1632 (34.1)</td>
</tr>
<tr>
<td>Fair</td>
<td>252 (7.6)</td>
<td>53 (9.7)</td>
<td>39 (15.9)</td>
<td>344 (6.6)</td>
</tr>
<tr>
<td>Poor</td>
<td>33 (1.4)</td>
<td>11 (2.6)</td>
<td>11 (8.3)</td>
<td>55 (2.1)</td>
</tr>
<tr>
<td>VA (VAS)</td>
<td>96 ± 10</td>
<td>95 ± 10*</td>
<td>93 ± 9***</td>
<td>96 ± 10</td>
</tr>
<tr>
<td><strong>CS (no glare)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5 cpd</td>
<td>36.4 ± 19.9</td>
<td>34.9 ± 21.1</td>
<td>34.0 ± 20.8</td>
<td>36.0 ± 20.2</td>
</tr>
<tr>
<td>3 cpd</td>
<td>67.2 ± 32.0</td>
<td>62.7 ± 31.2**</td>
<td>58.6 ± 34.3**</td>
<td>65.9 ± 32.2</td>
</tr>
<tr>
<td>6 cpd</td>
<td>31.9 ± 25.6</td>
<td>28.0 ± 24.5**</td>
<td>26.1 ± 25.8**</td>
<td>30.8 ± 25.5</td>
</tr>
<tr>
<td>12 cpd</td>
<td>6.6 ± 9.6</td>
<td>5.0 ± 9.1***</td>
<td>5.2 ± 14.1</td>
<td>6.2 ± 9.9</td>
</tr>
<tr>
<td>18 cpd</td>
<td>0.8 ± 2.7</td>
<td>0.6 ± 2.0*</td>
<td>0.2 ± 1.1***</td>
<td>0.7 ± 2.5</td>
</tr>
<tr>
<td><strong>CS (glare)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5 cpd</td>
<td>38.2 ± 19.1</td>
<td>35.4 ± 18.1**</td>
<td>33.9 ± 19.6**</td>
<td>37.5 ± 19.0</td>
</tr>
<tr>
<td>3 cpd</td>
<td>69.4 ± 32.8</td>
<td>63.9 ± 32.1**</td>
<td>57.1 ± 33.8***</td>
<td>67.6 ± 33.0</td>
</tr>
<tr>
<td>6 cpd</td>
<td>32.2 ± 25.1</td>
<td>28.7 ± 25.4**</td>
<td>24.3 ± 22.5***</td>
<td>31.1 ± 25.1</td>
</tr>
<tr>
<td>12 cpd</td>
<td>6.8 ± 10.2</td>
<td>5.6 ± 9.5***</td>
<td>4.2 ± 7.6***</td>
<td>6.5 ± 9.9</td>
</tr>
<tr>
<td>18 cpd</td>
<td>0.8 ± 2.7</td>
<td>0.6 ± 2.8*</td>
<td>0.2 ± 1.0***</td>
<td>0.7 ± 2.6</td>
</tr>
</tbody>
</table>

*P < 0.05, **P < 0.01, ***P < 0.001. Prevalence is weighted by age, sex and education to the Quarterly National Household Survey (2010) to ensure that data were nationally representative and further weighted by health status and sociodemographic factors to account for those who did not attend a health assessment. Regression analysis for continuous variables, chi squared analysis for categorical variables. No fear of falling (FOF) group was compared to the fear of falling with no activity restriction (FOF-NAR) group and the fear of falling with activity restriction (FOF-AR) group. ARMD, age-related macular degeneration; BMI, body mass index; cpd, cycles per degree; CS, contrast sensitivity; FOF, fear of falling; MMSE, Mini-Mental State Examination; SD, standard deviation; TUG, Timed Up-and-Go; VA, visual acuity; VAS, visual acuity scale.

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Discussion

The findings of the current study show that poorer self-reported vision was independently associated with FOF and FOF-related activity restriction, but that psychophysiologically measured vision (VA, CS) was not. FOF and self-reported vision were also linked to mobility impairment, but mesopic and photopic vision did not explain much of the relationship between FOF and mobility. These findings show that although participants’ perceptions of visual function are related to FOF and activity restriction, other visual (e.g., DP, VF, eye disease) or non-visual factors (e.g., cognitive processing) could be important determinants of self-reported vision.

However, reduced psychophysical visual function was associated with slower TUG in the FOF-related activity restriction group, illustrating the moderating effect of psychophysical vision on the relationship between FOF and mobility. FOF is associated with poorer function across multiple domains (physical, psychological, cognitive), and this is more pronounced in those with activity restriction. It is possible that reduced vision compounds the existing deficits in this group, resulting in greater mobility impairment. Viljainen et al. reported that when multiple self-reported sensory deficits
Fear of falling, vision and mobility

Table 3  Univariate and multivariate linear regression showing relationship between fear of falling, vision and log(Timed Up-and-Go) after adjusting for covariates

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\beta) (95% CI)</td>
<td>(\beta) (95% CI)</td>
<td>(\beta) (95% CI)</td>
</tr>
<tr>
<td>No FOF</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>FOF-NAR</td>
<td>0.113 (0.086, 0.141)**</td>
<td>0.037 (0.017, 0.058)**</td>
<td>0.034 (0.012, 0.055)**</td>
</tr>
<tr>
<td>FOF-AR</td>
<td>0.237 (0.183, 0.290)**</td>
<td>0.128 (0.084, 0.172)**</td>
<td>0.115 (0.073, 0.158)**</td>
</tr>
<tr>
<td>Self-reported vision</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>–</td>
<td>–</td>
<td>Reference</td>
</tr>
<tr>
<td>Very good</td>
<td>–</td>
<td>–</td>
<td>0.014 (−0.001, 0.029)</td>
</tr>
<tr>
<td>Good</td>
<td>–</td>
<td>–</td>
<td>0.017 (0.001, 0.033)*</td>
</tr>
<tr>
<td>Fair</td>
<td>–</td>
<td>–</td>
<td>0.040 (0.009, 0.071)*</td>
</tr>
<tr>
<td>Poor</td>
<td>–</td>
<td>–</td>
<td>0.097 (0.020, 0.175)*</td>
</tr>
<tr>
<td>VA (VAS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest (20–93)</td>
<td>–</td>
<td>–</td>
<td>–0.018 (−0.038, 0.002)</td>
</tr>
<tr>
<td>2(^{nd}) quartile (94–99)</td>
<td>–</td>
<td>–</td>
<td>–0.012 (−0.029, 0.004)</td>
</tr>
<tr>
<td>3(^{rd}) quartile (100–103)</td>
<td>–</td>
<td>–</td>
<td>–0.021 (−0.038, −0.004)*</td>
</tr>
<tr>
<td>Highest (104–115)</td>
<td>–</td>
<td>–</td>
<td>Reference</td>
</tr>
<tr>
<td>CS factor 1 (high frequencies)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest (−1.44 to −0.75)</td>
<td>–</td>
<td>–</td>
<td>0.002 (−0.023, 0.029)</td>
</tr>
<tr>
<td>2(^{nd}) quartile (−0.75 to −0.17)</td>
<td>–</td>
<td>–</td>
<td>−0.005 (−0.027, 0.017)</td>
</tr>
<tr>
<td>3(^{rd}) quartile (−0.17 to 0.54)</td>
<td>–</td>
<td>–</td>
<td>−0.014 (−0.031, 0.003)</td>
</tr>
<tr>
<td>Highest (0.54 to 7.80)</td>
<td>–</td>
<td>–</td>
<td>Reference</td>
</tr>
<tr>
<td>CS factor 2 (low frequencies)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest (−2.29 to −0.64)</td>
<td>–</td>
<td>–</td>
<td>0.007 (−0.020, 0.034)</td>
</tr>
<tr>
<td>2(^{nd}) quartile (−0.64 to −0.17)</td>
<td>–</td>
<td>–</td>
<td>0.012 (−0.010, 0.034)</td>
</tr>
<tr>
<td>3(^{rd}) quartile (−0.17 to −0.61)</td>
<td>–</td>
<td>–</td>
<td>0.009 (−0.010, 0.027)</td>
</tr>
<tr>
<td>Highest (0.61 to −3.85)</td>
<td>–</td>
<td>–</td>
<td>Reference</td>
</tr>
</tbody>
</table>

*\(P < 0.05; ** P < 0.01; *** P < 0.001. Model 1: Unadjusted linear regression. Model 2: Linear regression adjusted for age, sex, body mass index, education, medications, chronic conditions, history of falls, depressive symptoms, choice reaction time, word fluency, maximum grip strength, history of cataracts (treated or untreated), glaucoma, age related macular degeneration. Model 3: all vision variables entered simultaneously and adjusted as for Model 1. \(\beta\), coefficient; CI, confidence intervals; cpd, cycles per degree; CS, contrast sensitivity; FOF, fear of falling; FOF-AR, fear of falling with activity restriction; FOF-NAR, fear of falling with no activity restriction; TUG, Timed Up-and-Go; VA, visual acuity; VAS, visual acuity scale.

combined with FOF, there is an increased risk of developing walking difficulties.\(^{40}\)

The ability to maintain dynamic postural stability requires an interaction between the sensory and motor systems. TUG involves transfers, turning and walking, and therefore requires muscle strength and balance; therefore, it was speculated that vision might play a more important role in this task compared with straight line walking. In challenging balance situations, an individual relies on the visual system, particularly CS and DP, to gain information about body positions, movements and the environment to maintain stability.\(^{43}\) CS might also reflect the ability to detect and recognize objects in the environment, and see ground level obstacles more accurately.\(^{42}\) Visual functions, such as VA and CS, decrease with age\(^{40,44}\) as do cognitive processes such as executive function, processing speed and visual attention.\(^{55,46}\) Similar cognitive deficits have been observed in recurrent fallers, and could reflect a difficulty in coordination of the visual, cognitive and motor aspects required to negotiate the everyday environment.\(^{5}\) If an individual with reduced vision, especially CS, does not detect all of the environmental and body position information available, this might predispose them to cautious gait and/or a greater risk of falling. If a vision deficit is combined with FOF or other age-related factors, such as increased risk of osteoporosis, low muscle tone, poorer muscle strength, slow reaction times and postural instability, the risk of mobility impairment, falls and injury could be amplified even further.

Owsley \textit{et al.} found that age and CS at 6 cpd were the best predictors of the ability to detect and identify real-world targets, such as faces, signs and objects.\(^{68}\) Although the present results suggest that CS at both high and low frequencies are important for mobility, we are unaware of any research that has identified which spatial frequencies relate most closely to specific environmental objects that might affect mobility.
The main strength of the present study was the detailed, psychophysical measures of CS and VA obtained in a large, nationally representative population. However, the study also had some limitations. Given the restraints inherent in a multidisciplinary study of this size (e.g. participant time, cost), a fully comprehensive assessment within each domain was not feasible. Therefore, measures of visual function, such as VF and DP, along with other aspects of sensory function were not obtained, although they have been associated with FOF, falls and mobility in previous research, and therefore might have added to the analysis. Also, only those who attended a health assessment center were included, making the results directly applicable to community-dwelling adults, but not those who are housebound or resident in nursing homes and other facilities. These individuals are likely to have greater mobility limitations and to be in poorer health, so the relationship between FOF, vision and mobility might be different in this group. Finally, CS was tested under mesopic conditions, so the CS results are only directly applicable to low light conditions.

VA is the most commonly measured visual function, but it might not be the best indicator of functional vision. Everyday living involves low contrast conditions, suboptimal lighting and sources of glare, so including CS measurement could provide a more comprehensive visual assessment. Individual variations in CS have direct implications for older adults in terms of environmental modifications (floor surfaces, lighting), behaviors (switching on lights especially at night) and treatment of conditions associated with poor CS (e.g. cataract). Although reduced vision does not affect the mobility of those with no FOF or FOF without activity restriction, it does make those with FOF-related activity restriction more cautious, as evidenced by slower TUG. Reduced vision and FOF can lead to a self-imposed activity restriction, which can lead to social isolation, mobility limitations, loss of independence and increased fall risk. Therefore, the results of the present study suggest that clinicians should consider a comprehensive vision assessment including VA and CS, particularly in individuals with FOF, to prevent this transition to reduced activity.

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Disclosure statement

The authors declare no conflict of interest.

References

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