Characterizing Longitudinal Change in Physical Activity and Fear of Falling in Glaucoma

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Research

Keywords: aging, injury, mobility, risk of falling, steps, vision impairment

Posted Date: July 29th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-48989/v1>

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Abstract

Background: Older adults with visual impairments experience a higher risk of falling, and are more vulnerable to adverse health consequences associated with falls than those with normal vision. This study aims to characterize the longitudinal changes of objectively measured physical activity and self-reported fear of falling (FoF) related to types of falls in visually impaired older adults.

Methods: We obtained data from the Falls in Glaucoma Study (FIGS), a prospective cohort study that recruited 234 participants at the Johns Hopkins Wilmer Eye Institute from 2013 to 2015. Falls were defined as unintentionally coming to rest on the ground or a lower level, and injurious falls were determined through follow-up calls. Study participants were categorized into three groups – fallers with injurious consequences, fallers without injurious consequences, and non-fallers based on fall status in the first year. Physical activity was assessed using a waist-bound accelerometer (Actical). FoF was evaluated by questionnaire, with Rasch modeling generating FoF scores where higher scores reflected worse FoF. The three-year longitudinal changes of physical activity and FoF were modeled using mixed-effects models.

Results: In linear models fully adjusted for visual field damage and other covariates, physical activity among injurious fallers declined 425 steps/year (95% confidence interval [CI]: -793, -57), 13 active minutes/year (95% CI: -21, -6), and 3 minutes/year of moderate/vigorous activity (95% CI: -5, 0) more over the three-year study period compared to non-fallers; however, physical activity did not decline among non-injurious fallers. No longitudinal increases in FoF scores were observed in injurious or non-injurious fallers.

Conclusions: Among visually impaired older adults, injurious falls identified prospectively over 12 months contributed to a significant decline in physical activity over a three-year period, while no significant increases were observed for FoF. Further longitudinal research is warranted to better understand how different groups respond to falls, either via behavioral changes and/or changes in FoF, and to characterize the impact of reduced physical activity in fallers.

Background

Falls are the leading cause of morbidity and mortality among older adults worldwide [1]. More than 30% of community-dwelling adults aged 65 years or older fall at least once each year and half of these falls lead to some form of injury, including fractures, physical activity limitations, and less social engagement; each of which affects overall quality of life [2–5]. Older adults with reduced vision have a two-fold (or higher) risk of injurious and non-injurious falls compared to older adults without vision loss [6–9]. Understanding the long-term impact of injurious and non-injurious falls among visually impaired older adults is important for understanding the potential adverse outcomes resulting from falls in this high-risk population.

One potential downstream consequence of a fall is the restriction of physical activity. Numerous cross-sectional and prospective studies have noted that those who have recently fallen are at high risk for decline in physical activity [10], and those who engage less physical activity are more likely to experience recurrent falls [11, 12]. Physical activity is important to preserve after a fall given that it is a strong determinant of overall health [13, 14], and less active individuals demonstrate compromise in physical functioning [15], cognitive performance declines [16], and a higher risk of losing physical independence [17]. Although the importance of maintaining physical activity after events such as falls is clear, most previous research measured physical activity using self-reported questionnaires [11, 12, 18, 19], which introduce measurement error due to recall bias [20] and activity misclassification [21, 22]. More recently, the advent of wearable technology has created an opportunity to monitor real-world activity objectively [20, 23, 24]; such devices allow measurements of daily activity intensity and duration that are often overlooked using subjective questionnaires [25]. Of note, the specific impact of falls on longitudinal changes of physical activity has not been studied for specific high-risk populations, i.e., visually impaired older adults.

Another potential downstream consequence of a fall is the psychological consequence [26–30]. Fear of falling (FoF) often contributes to a low perceived ability to avoid falls and/or loss of confidence in ability to complete daily activities, thus becoming a driver of activity restriction [31]. Visually impaired persons with greater FoF are less physically active than those with less FoF [30]. Additionally, older adults with greater FoF are more likely to reduce travel outside the home, have less frequent social interaction, and transit to assisted living [29, 32–34]. Previous studies have noted cross-sectional associations between a history of falling and FoF in older adults [35]. As such, those reporting multiple falls or injurious falls are more likely to report FoF [28], but the impact of falls on long-term FoF, measured with a standard questionnaire and sensitive to evaluate changes in FoF across multiple activities, is not well understood, particularly for individuals with visual impairment.

Using data from the Falls in Glaucoma Study (FIGS), a prospective cohort study, we sought to characterize the three-year longitudinal changes of objectively measured physical activity and FoF related to types of falls (i.e. injurious vs. non-injurious) in visually impaired older adults. We hypothesized that participants who experienced either injurious or non-injurious falls in the initial one-year study period would demonstrate a greater decline in physical activity and increase in FoF over the full three-year observational period as compared to their counterparts who did not fall. Our findings can be used to guide therapies to prevent the deleterious consequences of falls, particularly for eye diseases (e.g., glaucoma) or other conditions where there is no restorative therapy.

Methods

Participants

Study participants were recruited from a single-center prospective cohort study known as FIGS (the Falls in Glaucoma Study) conducted at the Johns Hopkins Wilmer Eye Institute from 2013 to 2015. Briefly,

participants were eligible for the study if the following criteria were satisfied: (i) age 60 or older at the end of the study, (ii) lived within 60 miles of the hospital, (iii) diagnosed with glaucoma or suspected glaucoma, and (iv) were able to conduct visual field testing. Participants were excluded if they (i) had visual acuity worse than 20/40 resulting from any diseases other than glaucoma, (ii) were restricted to a bed or wheelchair, (iii) were hospitalized in the last month, or (iv) had ocular or non-ocular surgery within the last two months. We have described the detailed eligibility criteria in prior publications [36]. The study was approved by the Johns Hopkins Institutional Review Board and all participants provided written informed consent.

To determine the representativeness of FIGS population, the characteristics of participants were compared to the study-eligible population (258 patients) visiting the same hospital clinic over a one-week period. Recruited participants had similar age, race, sex, and visual field severity compared to study-eligible population, but were more likely to report falling within the last year (42% vs. 23%, $P < 0.01$), suggesting that our recruited participants had a higher risk of falls than the general study-eligible population.

Assessment of falls and injurious falls

Falls were defined for study participants as unintentionally coming to rest on the ground or a lower level, and further explained to participants using an instructional video [30, 37]. Participants were given falls calendars to begin using after their baseline assessment, and were asked to mark calendars daily to indicate whether a fall occurred or not. Subjects returned calendars every month. Injurious falls were distinguished from non-injurious falls via follow-up calls initiated after falls were reported by participants. An injurious fall was judged by the presence of one or more of the following: pain, bruising, swelling, pulled muscle, sprained ligament, joint dislocation, or fracture [38]. For this analysis, study participants were categorized into three groups – fallers with injurious consequences (injurious fallers), fallers without injurious consequences (non-injurious fallers), and non-fallers based on fall calendar data from the first year. Persons reporting one or multiple falls in the first study year were categorized as injurious fallers if any of the falls indicated an injury. None of the falls occurring in the first year had missing injury data.

Evaluation of physical activity and fear of falling

Physical activity was assessed at four annual intervals (baseline and each annual follow-up visit) using a waist-bound accelerometer (Actical, Respironics Inc., Murrysville, PA). Participants wore the accelerometer for seven-days annually and average daily activity was estimated to infer the amount of physical activity for that year. We restricted our analyses to time points in which at least four days of valid accelerometer data were available for analysis [39]. Steps during each one-minute interval were quantified by the accelerometer, which recorded activity in one-minute epochs. The intensity of motion during one-minute period was quantified as “counts”, an arbitrary unit transformed from total acceleration. The count data were used to classify physical activity level for each minute as sedentary, light, moderate or vigorous using the thresholds defined by Colley and Tremblay [40]. Daily moderate and vigorous physical activity

(MVPA) minutes were calculated as the sum of moderate and vigorous active minutes, and daily active minutes were identified as the sum of light and MVPA minutes.

FoF was also assessed four times (baseline and each annual follow-up visit) by the University of Illinois at Chicago FoF Questionnaire [41]. The 18 different tasks queried from easy activities (such as getting out of a car) to hard activities (such as walking on icy ground). For each task, participants selected one of three responses to indicate if they were “very worried”, “moderate or a little worried” or “not worried” about falling when performing given activity. We then applied Rasch models to match personal ability (i.e., person measure scores) to task difficulty (i.e., item measure scores) on the same linear scale using MPlus Version 7.0 [42, 43]. Both person measure and item measure scores were expressed in log-odds (logit) units [42]. Lower FoF scores reflected less FoF and higher scores reflected greater FoF. To obtain all FoF scores from the same Rasch model, we anchored FoF scores in follow-up visits to the baseline FoF score for each participant.

Visual assessment and characterization of covariates

Visual function was evaluated through visual acuity testing (ETDRS chart) and visual field testing (Humphrey HFA-2 perimeter [Carl Zeiss Meditec, Carlsbad, California, USA]). Integrated VF (IVF) sensitivity was derived by combining pointwise sensitivities from each eye to create a sensitivity at each spatial coordinate through the maximum sensitivity approach [36]. Next, we converted the decibel sensitivity values in the IVF to raw sensitivity values, then averaged all points in the full visual field, and retransformed average raw sensitivity back to decibel values to derive mean IVF sensitivity values. The average IVF in people with normal VFs was in the range of ≥ 31 dB, while < 31 dB indicated visual field damage. The severity of visual field damage was further classified as following: normal/mild (IVF > 28 dB), moderate (IVF 23–28 dB), or severe (IVF < 23 dB) [44].

Demographic characteristics including age, race, sex, living arrangement (living alone vs. living with another), and education were collected at baseline using a standard questionnaire. Polypharmacy was defined as using $\geq$ five non-eyedrop medications by direct observation of medication bottles or questionnaire. The number of comorbidities was the sum of comorbidities collected from a list of comorbid conditions described elsewhere [45]. Cognitive function was obtained using the Mini-Mental State Exam for visually impaired (MMSE-VI) questionnaire.

Statistical analysis

Study participants were included in the analyses if they had both valid accelerometer and FoF data at baseline, and at one or more of the three follow-up visits. Differences in demographic and clinical characteristics of study participants by fall status were evaluated using t-test for continuous variables and χ^2 test for categorical variables. Fitted plots of physical activity outcomes (including average steps, active minutes and MVPA minutes) and FoF scores over the three-year follow-up period were created to visualize the direction and magnitude of longitudinal changes in each fall group (Fig. 1A-D). Based on the appearance of the physical activity and FoF changes over time, linear mixed-effects models were used to study the longitudinal change in each outcome (average steps, active minutes, MVPA minutes and FoF)

as a function of first-year falls categorization (non-faller, non-injurious faller, or injurious faller) by including fall category, follow-up time (in years), and an interaction of falls category and follow-up time in each model. Other model covariates included age, IVF, race, sex, living arrangement, education, polypharmacy, comorbidity, and cognitive function. For all models, unstructured correlation models were employed and standardized residuals were compared to predicted values to ensure goodness of fit. Statistical significance was defined using two-sided hypothesis testing with α of 0.05. All analyses were performed using Stata STATA 15.0 (StataCorp LP, College Station, Texas, USA).

Results

For the 234 study participants, mean age was 70.5 (Standard Deviation [SD] = 7.6), 51.3% were men, 20.5% lived alone, and 85.2% had some college degree or higher. Mean IVF sensitivity was 27.1 dB (SD = 4.5 dB), and roughly half of participants had normal/mild vision field damage, while 40.6% and 10.3% had moderate and severe visual field damage, respectively. Nearly one third (32%) used five or more non-eye prescription medications, and the average MMSE-VI value was 20.0 (SD = 2.0). Over the first year, roughly half (54.7%) of participants were non-fallers, while 20.9% and 24.4% were classified as non-injurious fallers and injurious fallers, respectively (Table 1). Number of comorbidities varied across first-year fall status (ANOVA $p < 0.01$), with a higher proportion of injurious fallers describing two or more comorbidities (82%) as compared to non-fallers (57%) and non-injurious fallers (64%).

Table 1

Participant demographic and clinical characteristics by non-faller, non-injurious faller and injurious faller

	Non-faller N = 128	Non-injurious faller N = 49	Injurious faller N = 57	P-value
Demographic characteristics				
Age, mean (SD)	69.6 (7.8)	71.1 (7.8)	71.7 (7.0)	0.18
Male, n (%)	70 (55)	24 (50)	26 (46)	0.49
African American, n (%)	40 (31)	15 (31)	13 (23)	0.49
Live alone, n (%)	26 (20)	10 (20)	12 (21)	0.99
Education				0.78
≤ High school, n (%)	21 (16)	8 (16)	7 (12)	
Some college, n (%)	18 (14)	7 (14)	6 (11)	
Bachelor, n(%)	35 (27)	12 (25)	12 (21)	
≥ Master, n (%)	54 (42)	22 (45)	32 (56)	
Clinical characteristics				
IVF sensitivity, mean (SD)	27.1 (4.9)	26.7 (4.5)	27.3 (3.4)	0.75
Normal/mild VF damage (%)	64 (50)	22 (45)	29 (51)	
Moderate VF damage (%)	50 (39)	21 (43)	24 (42)	
Severe VF damage (%)	14 (11)	6 (12)	4 (42)	
Polypharmacy, n (%)	37 (32)	30 (32)	9 (38)	0.86
No. of comorbidities				0.01
≤ 1, n (%)	55 (43)	18 (37)	10 (18)	
2–3, n (%)	49 (38)	19 (39)	35 (61)	
4–5, n (%)	24 (19)	12 (25)	12 (21)	
MMSE-VI, mean (SD)	20 (2)	20 (2)	20 (2)	0.82
SD: standard deviation; IVF: integrated vision field (in decibels); VF: visual field; Normal/mild VF damage: IVF > 28 dB; Moderate VF damage: IVF: 23–28 dB; Severe VF damage: IVF < 23 dB; Polypharmacy: ≥ 5 systemic prescription medications; MMSE-VI: Mini-Mental State Examination-Vision Impairment (maximum as 22).				

Baseline physical activity measurements were available in all 234 participants, while 210 (89.7%), 190 (81.2%), and 171 (73.1%) had physical activity data available at the end of the 1st, 2nd, and 3rd study

years, respectively. Similarly, all participants completed FoF questionnaire in the first year, while 219 (93.6%), 199 (85.0%) and 182 (77.8%) completed the FoF after the 1st, 2nd, and 3rd study years, respectively.

When assessing activity changes over the three-year study period within groups defined by first-year fall status, average daily steps (-350 steps/year, 95% confidence interval [CI]: -653, -47) and active minutes (-10.9 minutes/year, 95% CI: -17.3, -4.5) declined for injurious fallers (Table 2); however, both steps and active minutes remained unchanged for non-fallers and non-injurious fallers ($p > 0.27$ for all) (Fig. 1A/1B). No significant changes in time spent in MVPA were noted within for any group ($p > 0.18$ for all) (Fig. 1C). When comparing activity changes over the three-year study period across groups, injurious fallers had 425 fewer steps/year (95% CI: -793, -57), 13.4 less active minutes/year (95% CI: -21.2, -5.6), and 2.5 less MVPA minutes/year (95% CI: -5.2, -0.1) compared to non-fallers (Table 2); non-injurious fallers, however, did not show significant differences in the three activity measures compared to non-fallers (including average steps, active minutes, MVPA minutes) ($p > 0.11$ for all).

Table 2
Longitudinal effect of physical activity and self-reported measures across fall status

Outcomes	Non-faller (β , 95% CI)	Non-injurious faller (β , 95% CI)	Injurious faller (β , 95% CI)	Difference between non-injurious vs non-faller (β , 95% CI)	Difference between injurious vs non-faller (β , 95% CI)
Physical activity					
Average steps	74.83 (-133.36, 283.02)	-11841 (-447.00, 210.19)	-349.93 (-653.24, -46.62)*	-193.24 (-582.14, 195.67)	-424.76 (-792.63, -56.90)*
Active minutes	2.50 (-1.93, 6.93)	-1.50 (-8.50, 5.50)	-10.89 (-17.33, -4.45)*	-4.00 (-12.29, 4.29)	-13.39 (-21.21, -5.57)*
Moderate & vigorous active minutes	1.04 (-0.46, 2.854)	-1.26 (-3.62, 1.11)	-1.47 (-3.66, 0.71)	-2.29 (-5.10, 0.51)	-2.51 (-5.16, -0.14)*
Self-reported measures					
Fear of falling	0.04 (0, 0.08)	0.06 (0, 0.13)	0.08 (0.02, 0.13)*	0.03 (-0.05, 0.10)	0.04 (-0.03, 0.11)
Mixed effects estimates adjusted for age, integrated vision field (IVF) sensitivity, race, sex, living arrangement, education, comorbidity, polypharmacy, and cognitive function.					
CI: confidence interval.					
*p < 0.05 by comparing with non-faller groups					

Significant increases in FoF over three-year study period were observed for injurious fallers (0.08 units/year, 95% CI: 0.02, 0.13), while no statistically significant increases were observed for non-fallers (0.04 units/year, 95% CI: 0, 0.08) or non-injurious fallers (0.06 units/year, 95% CI: 0, 0.13) (Fig. 1D). Greater FoF levels over time was not noted when comparing either injurious fallers (0.04 units, 95% CI: -0.03, 0.11) or non-injurious fallers (0.03 units, 95% CI: -0.05, 0.10) to non-fallers.

Model estimates for year-by-year values of physical activity and FoF measures across first year fall status were displayed in Table 3.

Table 3

Model estimated physical activity and self-reported measures at each follow-up time across fall status

Follow-up	Outcomes	Non-faller	Non-injurious faller	Injurious faller
Baseline	Average steps	3809.74	4282.95	4581.31
	Active minutes	139.43	149.12	171.45
	Moderate & vigorous active minutes	9.62	12.12	13.85
	Fear of falling	-0.03	0.09	0.07
1	Average steps	3926.36	4206.33	4273.17
	Active minutes	142.95	148.63	161.59
	Moderate & vigorous active minutes	10.88	11.09	12.61
	Fear of falling	0	0.15	0.14
2	Average steps	4019.95	4106.69	3942
	Active minutes	145.81	147.49	151.06
	Moderate & vigorous active minutes	12.08	10.00	11.30
	Fear of falling	0.04	0.21	0.21
3	Average steps	4111.67	4005.17	3608.96
	Active minutes	148.75	146.44	140.62
	Moderate & vigorous active minutes	13.19	8.82	9.90
	Fear of falling	0.08	0.28	0.29
Mixed effects estimates adjusted for age, integrated vision field (IVF) sensitivity, race, sex, living arrangement, education, comorbidity, polypharmacy, and cognitive function.				

Discussion

In a longitudinal study of changes in physical activity and FoF levels in persons with varying degrees of visual impairment, we found a long-lasting impact of falls on mobility (both physical activity and FoF) after injurious falls, but not after non-injurious falls. Specifically, first-year injurious falls were associated with a significant decline in physical activity over the three-year study period, but not with changes in FoF. However, non-injurious falls were not associated with a drop in physical activity nor a worsening of FoF over the full study period, nor were such changes observed in non-fallers. Our findings indicate that

among persons with visual impairment from glaucoma, injurious fallers lower their daily activity over time but do not demonstrate higher levels of FoF compared to their counterparts who do not fall.

Our results add to the published literature examining whether falls, or injuries occurring with falls, are associated with restriction of physical activity [4, 10]. A cross-sectional study from the Baltimore Longitudinal Study of Aging (BLSA) did not find associations between self-reported falls in the last year and accelerometer-defined physical activity [4]. However, the impact of fall status on the within-individual change in activity over time was not evaluated. Also, the retrospective assessment of falls via questionnaire is subject to substantial recall bias, i.e., those who recall their falls are more likely to sustain injuries, while less intense falls may be forgotten [46]. A three-year longitudinal study did find that injurious falls were associated with lower physical activity levels; however, physical activity was obtained by self-report, which typically shows very poor correlations with objective measures of physical activity [20–22], and is less reflective of important biological parameters such as BMI, diabetes and hypertension [47]. As such, our longitudinal study, which captured falls prospectively through monthly mail in calendars, and examined physical activity objectively over four annual visits, provides greater accuracy and is less subject to bias than prior studies. In the BLSA, investigators have demonstrated an average drop of 1.3% per year in overall activity from mid-to-late life [20], similar to our non-faller and non-injurious faller groups, but less than the decline observed in our injurious fallers (roughly 7% fewer steps and 7% fewer active minutes per year).

Our study also examined whether fall status was associated with changes in FoF over time. Previous research has demonstrated that any falls reported within the last 3 or 12 months were associated with a higher likelihood of FoF, as judged by the individual's response to the question “do you ever limit activities because you are afraid of falling?”²⁴ or “have you been worried or afraid that you might fall?” [48] The use of a single question to evaluate FoF will have less precision for measuring within-person changes in FoF as compared to the current approach which uses a reliable and valid questionnaire that enables quantifying FoF levels and changes in levels resulting from falls. Our study demonstrated that first-year injurious fallers had significant worsening of FoF over the three year study period; however, worsening of FoF at a rate just short of statistical significance was also observed in the non-faller and non-injurious faller groups, and the rate of FoF changes over time were not significantly different between those with injurious falls, non-injurious falls, or no falls over the first study year. Thus, it is not clear that fall-related injuries, when evaluated over a single study year, have a clear influence on the longitudinal trajectory of FoF, though it remains possible that severe injuries and/or repeated falls may impact FoF over time.

Our findings strongly suggest that injurious falls have significant consequences versus those experiencing a fall that is non-injurious. Injurious falls in this study were associated with reductions in physical activity over the three-year study period. Specifically, an individual who had one or more injurious falls in the first year reduced their walking over the three-year study period by an average of 350 steps/year, and demonstrated average 11 fewer daily active minutes per year. An observational study of 8188 healthy women aged 70–75 in Australia reported that lower physical activity was associated with an increased risk of fall-related bone fracture [11]; our findings emphasize these relationships could be

reciprocal, with fall-related injuries also resulting in less physical activity. Of note, the present study suggests that fall-related injuries may contribute to functional decline over a long period extending well past the fall occurrence (up to 3 years).

The magnitude of activity change (average of 350 steps/year and 11 active minutes/year over the three-year study period) in injurious falls is significant given that previous studies report that 30 fewer daily minutes of walking is associated with a 23% higher risk of coronary heart disease [49], and fewer steps per day is significantly associated with higher all-cause mortality (hazard ratio = 2.04 for 4000 steps/day vs. 8000 steps/day) [50]. We also observed an average of 1.5 fewer minutes of MVPA/day (roughly 10 fewer weekly minutes) each year for injurious fallers, which is substantial given that World Health Organization (WHO) recommends older adults should conduct at least 150 minutes of moderate-intensity physical activity a week to maintain functional capability and overall well-being [51]. Our data add compelling evidence about the impact of substantial mobility declines associated with injurious falls on longevity and well-being, which supports the need for interventions to prevent injurious falls and rehabilitation programs to enhance the recovery from any detrimental effects of falls, particularly with regards to safely resuming/increasing physical activity [52, 53].

Our study has several limitations. First, study participants were recruited from one study site and had varying degrees of glaucoma; therefore our results may not be generalizable to all visually impaired older people, or patients without visual impairments. As such, it remains unclear whether any fall occurrences with respect to other illnesses (other than visual damage) also influence the longitudinal change of physical activity and FoF in the same manner. Additionally, other factors (e.g., home hazard modification) [52] might confound the association between falls status and activity in observational studies, though such factors would only affect results if they were differential across fall status. Moreover, such changes, if protective, would tend to bias our results towards the null. Finally, it was our original hypothesis (set forth in our grant) that first-year fall events would have implications for physical activity and fear of falling over the full 3 year study period (declines were still expressed as change per year, given that complete follow-up was not present in all participants). However, it is quite possible, perhaps even likely, that the impact of injurious falls varied over time. Indeed, it might appear from Fig. 1A that injurious falls caused physical activity to decline in the year of the fall, with these declines sustained in later years, while non-injurious falls created a decline that was temporary. We did not formally test the significance of these trends noted post-hoc, though they should be evaluated in future studies.

In summary, our study found that in glaucoma patients, injurious falls contributed to a substantial change in physical activity over the three-year study period, although FoF levels remained unchanged. However, non-injurious falls were associated with neither a drop in physical activity over the full study period nor worsening of FoF. Further work is needed to identify effective interventions to prevent injurious falls and evaluate rehabilitation programs to improve physical and mental recovery from falls, particularly those resulting in injury.

Declarations

Declarations

Ethics approval and consent to participate

The study was approved by the Johns Hopkins Institutional Review Board and all participants

Consent for publication

Not applicable.

Availability of data and material

The data used this study are available from Dr. Pradeep Y. Ramulu on reasonable request in accordance with the publications and presentations policy.

Competing interests

The authors declare that they have no competing interests.

Funding

The research was supported by National Institutes of Health Grant EY022976. The funding agency had no role in design, conduct, analysis and interpretation of the findings for this study.

Authors' contributions

JE: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Validation, Visualization, Writing - original draft, Writing - review & editing. AM: Data curation, Project administration, Validation, Writing - review & editing. JS: Conceptualization, Methodology, Supervision, Writing - review & editing. TL: Conceptualization, Methodology, Supervision, Writing - review & editing. DF: Funding acquisition, Methodology, Validation, Writing - review & editing. SW: Funding acquisition, Methodology, Validation, Writing - review & editing. LG: Funding acquisition, Methodology, Validation, Writing - review & editing. PY: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing - review & editing.

Acknowledgements

We thank the Falls in Glaucoma Study participants, staff and investigators.

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Figures

Figure 1

A: Average daily steps by fall status at each assessment over the three-year follow-up period. B: Active minutes by fall status at each assessment over the three-year follow-up period. C: Moderate & vigorous active minutes by fall status at each assessment over the three-year follow-up period. D: Rasch-derived fear of fall scores by fall status at each assessment over the three-year follow-up period.