

The Association Between Sedentary Behavior and Eye Diseases: A Prospective Study from the UK Biobank

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Research Article

Keywords: Sedentary behavior, age-related macular degeneration, glaucoma, dry eye disease, retinal vein occlusion, UK Biobank

Posted Date: June 11th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-9780388/v1>

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Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at BMC Public Health on August 8th, 2026. See the published version at <https://doi.org/10.1186/s12889-026-28869-x>.

Abstract

Background

Sedentary behavior (SB) is a well-established risk factor for multiple chronic non-communicable diseases. However, evidence regarding its association with common ocular disorders remains limited and inconsistent. This study aimed to investigate the prospective associations between SB and the risks of incident age-related macular degeneration (AMD), glaucoma, dry eye disease (DED), and retinal vein occlusion (RVO).

Methods

We conducted a prospective cohort analysis using data from the UK Biobank. Eligible participants included individuals with complete information on SB, physical activity (PA), and sleep duration. Separate analytical cohorts were established for each ocular outcome, and participants with a pre-existing diagnosis of the corresponding disease at baseline were excluded. Incident cases were identified through hospital inpatient records and self-reported data. Cox proportional hazards models were used to examine the associations between AMD, glaucoma, DED, RVO and SB.

Results

In unadjusted models, prolonged sedentary time was associated with increased risks of AMD, glaucoma, and RVO. However, after comprehensive adjustment for sociodemographic characteristics, lifestyle factors, and metabolic parameters, only a borderline statistically significant association persisted between sedentary time and AMD risk (HR = 1.01; 95% CI: 1.00–1.02), whereas no significant associations were observed for glaucoma, DED, or RVO. restricted cubic spline (RCS) analyses demonstrated mild J-shaped nonlinear associations between sedentary time and both AMD and glaucoma, with the lowest risk observed at approximately 3.7 hours/day; however, these associations were attenuated and became nonsignificant after full multivariable adjustment. Stratified interaction analyses identified significant effect modification only for AMD, with body mass index (BMI), glycated haemoglobin (HbA1c), and physical activity level significantly interacting with SB. Sensitivity analyses yielded findings largely consistent with the primary analyses.

Conclusion

After comprehensive adjustment for potential confounders, no robust, independent, or consistently significant associations were observed between sedentary time and the incidence of AMD, glaucoma, DED, or RVO. These findings suggest that the observed associations between SB and ocular diseases may largely reflect shared underlying mechanisms, including broader patterns of unhealthy lifestyle

behaviors and cumulative metabolic risk burden, rather than a direct causal effect of sedentary time itself in the pathogenesis of these conditions.

Background

With the accelerating global aging population and increasing burden of chronic diseases, various ocular disorders have become major causes of visual impairment and blindness worldwide. Age-related macular degeneration (AMD), glaucoma, dry eye disease (DED), and retinal vein occlusion (RVO) are highly prevalent among middle-aged and older adults, substantially impairing quality of life and imposing considerable socioeconomic burdens [1–6]. Although these diseases differ in clinical manifestations and primary pathogenic mechanisms, accumulating evidence suggests that they share several common pathological processes, including chronic low-grade inflammation, oxidative stress, microcirculatory dysfunction, and neurodegenerative alterations [3, 7–11]. These convergent mechanisms imply that multiple ocular diseases may be influenced by common upstream modifiable risk factors.

Sedentary behavior (SB), defined as any waking behavior characterized by an energy expenditure of ≤ 1.5 metabolic equivalents (METs) while in a sitting or reclining posture, represents an important modifiable lifestyle factor [12, 13]. Extensive epidemiological evidence has demonstrated that prolonged SB is independently associated with increased risks of cardiovascular disease, metabolic dysfunction, and all-cause mortality [14–18]. Proposed biological mechanisms include systemic inflammatory activation, metabolic dysregulation, and adverse hemodynamic alterations [19–22], all of which may adversely affect ocular tissues. For example, oxidative stress contributes to retinal injury and neurodegenerative changes, which are hallmark features of AMD and glaucoma [9, 23–25]; chronic inflammation may compromise ocular surface integrity and excessive near-work and screen exposure can disrupt tear film stability, thereby promoting the development and progression of DED [7, 26]; and impaired venous hemodynamics may predispose individuals to RVO [3, 11]. Collectively, SB may contribute to the development and progression of multiple ocular diseases through both systemic and localized ocular pathways.

Nevertheless, current evidence remains limited and inconsistent. Existing studies, most of which are based on small- to moderate-sized cohorts, have reported conflicting associations between SB and ocular outcomes. Notably, among studies investigating the relationship between SB and DED [4, 27–29], three reported positive associations [4, 27, 28], whereas another identified an inverse association [29], leaving the direction and magnitude of this relationship uncertain. Given the increasing recognition of lifestyle determinants in ocular health, large-scale prospective studies systematically evaluating the associations between SB and multiple common eye diseases are urgently needed.

Therefore, the objective of this study is to investigate the prospective associations between objectively assessed sedentary time and the risks of incident AMD, glaucoma, DED, and RVO using data from the UK Biobank.

Methods

2.1 Study Population

This study utilized data from the UK Biobank, a large prospective cohort study involving more than 500,000 individuals aged 37 to 73 years from 22 assessment centers across the United Kingdom between 2006 and 2010 [30]. Detailed descriptions of the study design, participant recruitment, data collection procedures, and quality control protocols have been previously documented [31]. Ethical approval of UK biobank study was obtained from the North West Multicenter Research Ethics Committee, and all participants involved provided written informed consent before enrollment.

Among the initial 502,166 participants with baseline data available, 120,517 individuals with missing data on SB, physical activity (PA), and sleep duration were excluded. An additional 6,428 participants with implausible or biologically inconsistent time-use data (e.g., total daily time allocation exceeding 24 hours) were further excluded. For each outcome-specific analysis, participants with a pre-existing diagnosis of the corresponding eye disease at baseline were excluded to ensure the ascertainment of incident cases. A detailed flowchart of participant selection is shown in Fig.S1 (Additional file 1).

2.2 Assessment of Sedentary Behavior

At baseline, participants self-reported their average daily duration of three mutually exclusive sedentary activities: television viewing, recreational computer use (excluding work-related use), and driving. Total SB time was calculated as the sum of these three components. To reduce measurement error attributable to extreme reporting, daily SB values exceeding 18 hours were top-coded at 18 hours, consistent with previous epidemiological studies [32, 33]. Participants whose combined reported duration of SB, sleep, and moderate-to-vigorous physical activity exceeded 24 hours/day were excluded, as such reports are physiologically implausible and suggestive of systematic reporting bias.

2.3 Outcome Ascertainment

The primary outcomes were incident AMD, glaucoma, DED, and RVO. Outcomes were identified using International Classification of Diseases Tenth Revision (ICD-10) coding system and self-reported information during follow-up. The corresponding codes and self-reported field codes are listed in Table S1 (Additional file 1).

Follow-up commenced at baseline assessment and continued until the earliest occurrence of the following events: (i) first confirmed diagnosis of the relevant ocular outcome; (ii) death, ascertained through death registries; or (iii) administrative censoring (March 21, 2023, for England, May 31, 2022, for Wales, and August 31, 2022, for Scotland).

2.4 Covariates

Covariate information was inquired by baseline questionnaire including age, sex, ethnicity, education, annual household income smoking and drinking status, body mass index (BMI), blood pressure, glycated

haemoglobin (HbA1c), and total cholesterol. Missing covariate data were handled as follows: household income was modeled as a categorical variable with an additional “missing” category, whereas all other continuous or categorical variables with missingness < 10% were imputed using multiple imputation by chained equations. Detailed definitions of these variables were described in Table S2 (Additional file 1).

2.5 Statistical Analysis

The baseline characteristics of UK Biobank participants were summarized overall and according to tertiles of total sedentary time. Categorical variables are presented as frequencies and percentages, whereas continuous variables are expressed as means $\pm$ standard deviations (SDs). Cox proportional hazards regression models were conducted to examine the longitudinal associations between SB and incident ocular diseases. Three hierarchical models were constructed: Model 1, with no covariate adjustment; Model 2, adjusted for age and sex; and Model 3, fully adjusted for age, sex, ethnicity, education, household income, smoking status, alcohol consumption, BMI, systolic blood pressure, HbA1c, and total cholesterol.

To evaluate potential nonlinear dose–response relationships between SB and ocular diseases risk, we performed restricted cubic spline (RCS) analysis with three knots, treating sedentary time as a continuous exposure. Nonlinearity was assessed using likelihood ratio tests comparing RCS models with corresponding linear models., and subsequent inclusion of continuous or grouped variables was determined on the basis of the results.

Subgroup and interaction analyses were conducted across prespecified effect modifiers, including sex, age (< 60 vs. ≥ 60 years), BMI (< 25 vs. 25–29.9 vs. ≥ 30 kg/m²), HbA1c (< 39 vs. 39–47 vs. ≥ 48 mmol/mol), and physical activity level (meeting vs. not meeting World Health Organization [WHO] recommendations). Interaction terms were incorporated into Model 3, and statistical significance was assessed using Wald tests. Cumulative incidence functions (CIFs), accounting for the competing risk of death, were estimated and visualized according to SB groups. To minimize potential reverse causality, sensitivity analyses excluding events occurring within the first two years of follow-up were additionally performed.

The proportional hazards assumption was assessed using Schoenfeld residuals and log–log survival plots. All analyses were carried out using R software (version 4.5.2). A 2-sided *P*-value of less than 0.05 was considered statistically significant.

Results

3.1 Baseline Characteristics

Analyses were conducted within outcome-specific incident cohorts, with participants with prevalent AMD (n = 669), glaucoma (n = 4,224), DED (n = 625), or RVO (n = 625) at baseline excluded from the

corresponding analyses. Consequently, the analytical sample sizes varied slightly across outcomes, as shown in Table S3 (Additional file 1).

Baseline characteristics stratified by tertiles of SB are summarized in Table S4-S7 (Additional file 1). Compared with participants in the lowest tertile of SB, those in the highest tertile were more likely to be male, have lower educational attainment and household income, report current smoking, exhibit higher BMI and HbA1c levels, and engage in lower levels of moderate-to-vigorous physical activity. These findings highlight the strong correlation between SB and multiple sociodemographic and metabolic factors.

3.2 Associations Between Sedentary Time and Risk of Eye Diseases

In Cox regression models treating SB as a continuous exposure, Model 1 demonstrated significant positive associations between sedentary time and the risks of AMD, glaucoma, and RVO (all $p < 0.05$), whereas no significant association was observed for DED. After adjustment for age and sex in Model 2, the effect estimates were attenuated, and a nominally significant association emerged for DED (HR = 1.03, 95% CI: 1.01–1.06, $p = 0.014$). Following further multivariable adjustment in Model 3, all associations were substantially attenuated. Only the association with AMD remained borderline statistically significant (HR = 1.01, 95% CI: 1.00–1.02, $p = 0.042$), whereas the associations with glaucoma (HR = 1.01, 95% CI: 1.00–1.02), DED (HR = 1.02, 95% CI: 1.00–1.05), and RVO (HR = 1.02, 95% CI: 0.99–1.05) were no longer statistically significant (all $p > 0.05$) (Table 1).

Table 1
The associations between sedentary time and AMD, glaucoma, DED and RVO.

Model	AMD		Glaucoma		DED		RVO	
	HR (95%CI)	P value	HR (95%CI)	P value	HR (95%CI)	P value	HR (95%CI)	P value
Model 1 ^a	1.02 (1.01–1.03)	<0.001	1.02 (1.01–1.03)	<0.001	1.01 (0.99–1.04)	0.291	1.05 (1.02–1.08)	0.002
Model 2 ^b	1.03 (1.02–1.04)	<0.001	1.02 (1.00–1.02)	0.003	1.03 (1.01–1.06)	0.014	1.03 (1.00–1.07)	0.034
Model 3 ^c	1.01 (1.00–1.02)	0.042	1.01 (1.00–1.02)	0.078	1.02 (1.00–1.05)	0.113	1.02 (0.99–1.05)	0.192
HR: Hazard ratio; CI: Confidence interval								
a: Without adjustment								
b: Adjusted for age and sex								
c: Adjusted for age, sex, ethnicity, education, household income, smoking status, alcohol consumption, body mass index, systolic blood pressure, HbA1c, and total cholesterol								

RCS models were subsequently applied to evaluate the potential nonlinear associations between sedentary time and the risks of multiple ocular diseases.

RCS analyses identified significant nonlinear associations for AMD and glaucoma (p for nonlinearity<0.05), characterized by mild J-shaped relationships (Fig. 1A,1B). The lowest risk was observed at approximately 3.67 hours/day of sedentary time for AMD and 3.78 h/day for glaucoma, with risk gradually increasing beyond this threshold. At higher levels of sedentary time (> 5 h/day), the risk exhibited a progressively increasing trend; however, the confidence intervals became relatively wider at the extreme upper range of exposure. In contrast, the RCS curves for DED and RVO demonstrated monotonic but nonsignificant upward trends without evident inflection points, and the 95% CIs consistently overlapped the null value (HR = 1.0) across the exposure range (Fig. 1C,1D).

Based on the RCS findings, SB was categorized into three groups for AMD and glaucoma analyses (< 3 hours/day, 3–5 hours/day, and > 5 hours/day). In Model 1, high SB was associated with increased risks

of AMD (HR = 1.26, 95% CI: 1.17–1.36) and glaucoma (HR = 1.20, 95% CI: 1.13–1.29) (both $p < 0.001$). After adjustment for age and sex in Model 2, the association with AMD remained significant (HR = 1.12, 95% CI: 1.04–1.20, $p = 0.002$). However, after full multivariable adjustment in Model 3, neither association remained statistically significant (AMD: HR = 1.03, 95% CI: 0.96–1.11, $p = 0.383$; glaucoma: HR = 1.01, 95% CI: 0.94–1.08, $p = 0.802$), and trend tests were nonsignificant for both outcomes (Table 2).

Table 2					
The associations between AMD, glaucoma and RCS-based SB groups.					
Model	SB level	AMD		Glaucoma	
		HR (95%CI)	<i>P</i> value	HR (95%CI)	<i>P</i> value
Model 1 ^a	Moderate	1.13(1.05–1.21)	<0.001	1.06(0.99–1.13)	0.075
	High	1.26(1.17–1.36)	<0.001	1.20(1.13–1.29)	<0.001
Model 2 ^b	Moderate	1.01(0.94–1.08)	0.758	0.95(0.90–1.02)	0.165
	High	1.12(1.04–1.20)	0.002	1.03(0.96–1.10)	0.367
Model 3 ^c	Moderate	0.98(0.92–1.06)	0.682	0.96(0.90–1.02)	0.19
	High	1.03(0.96–1.11)	0.383	1.01(0.94–1.08)	0.802
HR: Hazard ratio; CI: Confidence interval; SB: sedentary behavior					
a: Without adjustment					
b: Adjusted for age and sex					
c: Adjusted for age, sex, ethnicity, education, household income, smoking status, alcohol consumption, body mass index, systolic blood pressure, HbA1c, and total cholesterol					

Collectively, these findings suggest that the observed associations between sedentary time and ocular disease risk are largely explained by sociodemographic and metabolic confounding factors rather than reflecting a direct and independent effect of SB itself.

Based on the RCS findings, subsequent analyses for AMD and glaucoma were conducted using categorical SB variables defined according to the RCS-derived inflection points, whereas sedentary time was retained as a continuous variable in the analyses of DED and RVO.

3.3 Subgroup and Interaction Analyses

Interaction analyses were conducted to evaluate potential effect modification in the associations between sedentary time and ocular disease risks across different population characteristics, including sex, age, BMI, HbA1c, and physical activity level. Overall, the interaction analyses did not reveal a consistent pattern of effect modification across the different ocular outcomes.

Formal interaction analyses identified significant effect modification for AMD by BMI, HbA1c, and PA level, whereas no significant interactions were observed for sex or age. In contrast, no significant interactions were detected for glaucoma, DED, or RVO across any of the examined effect modifiers (Additional file 1: Table S8-S9).

The subgroup analyses were generally consistent with the interaction findings. Among participants meeting the WHO recommendations for physical activity, high SB was associated with a 12% increased risk of AMD (HR = 1.12, 95% CI: 1.02–1.24, $p = 0.02$). By comparison, no significant association was observed among individuals who did not meet the physical activity recommendations. No consistent heterogeneity across sex or age strata was observed for any ocular outcome. For glaucoma, DED, and RVO, effect estimates remained close to the null across all subgroups, with 95% CIs consistently crossing unity (Additional file 1: Table S10-S11).

These findings indicate that the relationship between SB and ocular health may vary according to disease type, with evidence of context-dependent effect modification observed only for AMD.

3.4 Sensitivity and Competing-Risk Analyses

Sensitivity analyses excluding events occurring within the first two years of follow-up did not materially alter the primary findings. All effect estimates shifted closer to the null, and none of the associations remained statistically significant in the fully adjusted models (Additional file 1: Table S12).

Cumulative incidence functions (CIFs) analyses accounting for the competing risk of death (Additional file 1: Fig.S2) demonstrated gradual separation of incidence curves over time for AMD, glaucoma, and RVO, with the highest cumulative incidence observed in the high-SB group and the lowest incidence in the low-SB group. The moderate-SB group exhibited intermediate risk levels. In contrast, no clear separation of CIF curves was observed for DED. However, this trend was not consistently supported in the multivariable regression models.

Discussion

Drawing on the large-scale prospective UK Biobank cohort, this study systematically examined the associations between sedentary behavior and multiple prevalent eye diseases, including AMD, glaucoma, DED, and RVO. After comprehensive adjustment for sociodemographic characteristics, lifestyle factors, and metabolic parameters, no statistically robust or independent associations were observed between objectively assessed sedentary time and any of the evaluated ocular outcomes.

Prior epidemiological evidence has consistently linked prolonged sedentary behavior with elevated risks of a range of adverse systemic health outcomes, including cardiovascular disease, metabolic disorders, and all-cause mortality [14–18]. Notably, recent studies using objective accelerometer-derived measurements have demonstrated that higher sedentary time remains associated with increased disease risk, even among individuals meeting current physical activity guidelines, suggesting a

potentially independent pathophysiological role of sedentary behavior [14, 34–37]. In contrast, evidence regarding its impact on ocular health remains limited, heterogeneous, and inconclusive.

Against this backdrop, our findings provide novel, rigorously adjusted evidence to the literature. We observed no consistent or independent associations between sedentary behavior and any of the four eye diseases across primary multivariable models and multiple sensitivity analyses, including alternative exposure definitions, exclusion of early-onset cases, and stratification by physical activity level. In comparison, advancing age and HbA1c showed strong, statistically significant, and directionally consistent associations across all outcomes, indicating that aging and underlying metabolic dysregulation are likely the dominant determinants of ocular disease risk [38–41], whereas sedentary behavior appears to exert only a limited direct effect.

From a mechanistic perspective, although sedentary behavior is implicated in insulin resistance, chronic low-grade inflammation, and endothelial dysfunction [19, 20], these pathways are hypothesized to influence ocular disease risk primarily through downstream metabolic disturbances rather than direct effects on ocular tissues. For example, the pathogenesis and progression of AMD and RVO involve complex, long-term local processes, including retinal microvascular remodeling, oxidative stress accumulation, and neuroinflammatory activation [3, 9], which are less likely to be directly or acutely driven by sedentary exposure. Consistent with this interpretation, the magnitude of association between sedentary time and ocular outcomes was markedly attenuated after adjustment for key metabolic covariates (e.g., HbA1c, BMI, and systolic blood pressure), further supporting the hypothesis that sedentary behavior primarily acts as a mediator—or upstream contributor—of metabolic dysfunction, rather than as an independent causal factor in the development of eye diseases.

Interestingly, significant interactions were observed only for AMD, particularly with BMI, HbA1c, and physical activity level. These findings may indicate that susceptibility to the adverse effects of SB differs according to underlying metabolic status and behavioral context. Nonetheless, given the relatively modest effect sizes and the absence of consistent associations across analyses, these findings should be interpreted cautiously. Moreover, no clear dose–response relationship or stable nonlinear association was observed in the present study, which differs from the threshold effects reported in some cardiovascular studies [42–44]. This may suggest that the impact of sedentary behavior on ocular diseases is relatively modest, or that measurement error inherent to self-reported sedentary behavior may have attenuated the true underlying associations.

The strengths of this study include its prospective design, large sample size and long follow-up duration, which enhanced statistical power and, to some extent, supported the temporal relationship between exposure and outcomes. In addition, potential confounding factors were comprehensively assessed and carefully controlled for throughout the analyses. Furthermore, the inclusion of multiple common ocular outcomes enabled a more comprehensive evaluation of the potential impact of sedentary behavior on ocular health at an overall population level.

Several limitations should also be acknowledged. First, as an observational study, although the prospective design partially supports the temporal sequence between exposure and outcome, causal relationships cannot be definitively established. SB was assessed using self-reported questionnaires, which may introduce recall bias and exposure misclassification. Second, despite adjustment for a broad range of demographic and metabolic covariates, residual confounding by unmeasured or imperfectly measured variables, including occupational characteristics, dietary factors, and screen exposure patterns, cannot be completely excluded. Third, SB and other covariates were measured only at baseline and may have changed over time, potentially resulting in exposure misclassification during follow-up. Fourth, outcome ascertainment primarily relied on hospital-based records and ICD-10 coding, which may underestimate milder or undiagnosed cases, particularly for DED. Finally, because the UK Biobank predominantly comprises middle-aged and older adults of White European ancestry, the generalizability of these findings to younger or more ethnically diverse populations may be limited.

Overall, our findings suggest that SB is unlikely to represent a direct and independent risk factor for AMD, glaucoma, DED, or RVO. Instead, the observed associations appear to be largely attributable to broader metabolic dysfunction and unhealthy lifestyle patterns associated with prolonged sedentary time. Therefore, interventions targeting SB alone may provide limited benefits for ocular disease prevention. More comprehensive strategies addressing metabolic health, behavioral risk factors, and lifestyle modification may be required to improve long-term ocular health outcomes.

Conclusion

Using data from the UK Biobank prospective cohort, this study found no robust, consistent, or statistically significant independent associations between objectively assessed sedentary time and the risks of incident AMD, glaucoma, DED, or RVO after comprehensive adjustment. These findings support the interpretation that SB may function primarily as a marker of systemic metabolic burden and unfavorable lifestyle patterns rather than as an independent causal determinant of ocular disease. Future studies should prioritize longitudinal mediation analyses to clarify the pathways linking SB with metabolic dysregulation and should incorporate rigorous intervention studies together with advanced causal inference approaches to further elucidate the etiological role of SB in ocular disease prevention.

Abbreviations

SB: Sedentary behavior

AMD: age-related macular degeneration

DED: dry eye disease

RVO: retinal vein occlusion

PA: physical activity

HR: Hazard ratio

CI: Confidence interval

RCS: Restricted cubic spline

BMI: Body mass index

HbA1c: glycated haemoglobin

MET: Metabolic equivalents

ICD: International Classification of Diseases

SD: Standard deviation

WHO: World Health Organization

CIF: Cumulative incidence function

Declarations

Availability of data and materials

Data are available in a public, open access repository. All UK Biobank information is available online (<https://www.ukbiobank.ac.uk/>). This research has been conducted using the UK Biobank Resource under Application Number 170202.

Acknowledgements

This research has been conducted using the UK Biobank resource. The most important acknowledgment is to the participants in the study and the members of the UK Biobank cohort.

Funding

This research received no external funding.

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Contributions

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Ethics declarations

Ethics approval and consent to participate

The UK Biobank study obtained approval from the North West Multi-Center Research Ethics Committee (21/NW/0157). All participants gave written informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Supplementary Information

Additional file 1: Fig.S1. Flowchart for the selection of the analyzed study sample from the UK Biobank study. Table S1. Disease codes of AMD, glaucoma, DED, RVO in UK Biobank. Table S2. The resource and definition of the selected covariates (except for age, and sex). Table S3. The numbers of participants and outcome events for AMD, glaucoma, DED and RVO. Table S4. Baseline characteristics of UK Biobank participants by sedentary time in AMD study. Table S5. Baseline characteristics of UK Biobank participants by sedentary time in glaucoma study. Table S6. Baseline characteristics of UK Biobank participants by sedentary time in DED study. Table S7. Baseline characteristics of UK Biobank participants by sedentary time in RVO study. Table S8. Interaction analyses for the associations between sedentary time and AMD, glaucoma across different population characteristics. Table S9. Interaction analyses for the associations between sedentary time and DED, RVO across different population characteristics. Table S10. The associations of sedentary behavior with AMD and glaucoma stratified by different population characteristics. Table S11. The associations of sedentary behavior with DED and RVO stratified by different population characteristics. Table S12. The associations of sedentary behavior with AMD, glaucoma, DED and RVO after excluding participants with less than 2 years of follow-up. Fig.S2. Incidence curves by the cumulative incidence functions accounting for the competing risk of death.

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Figures

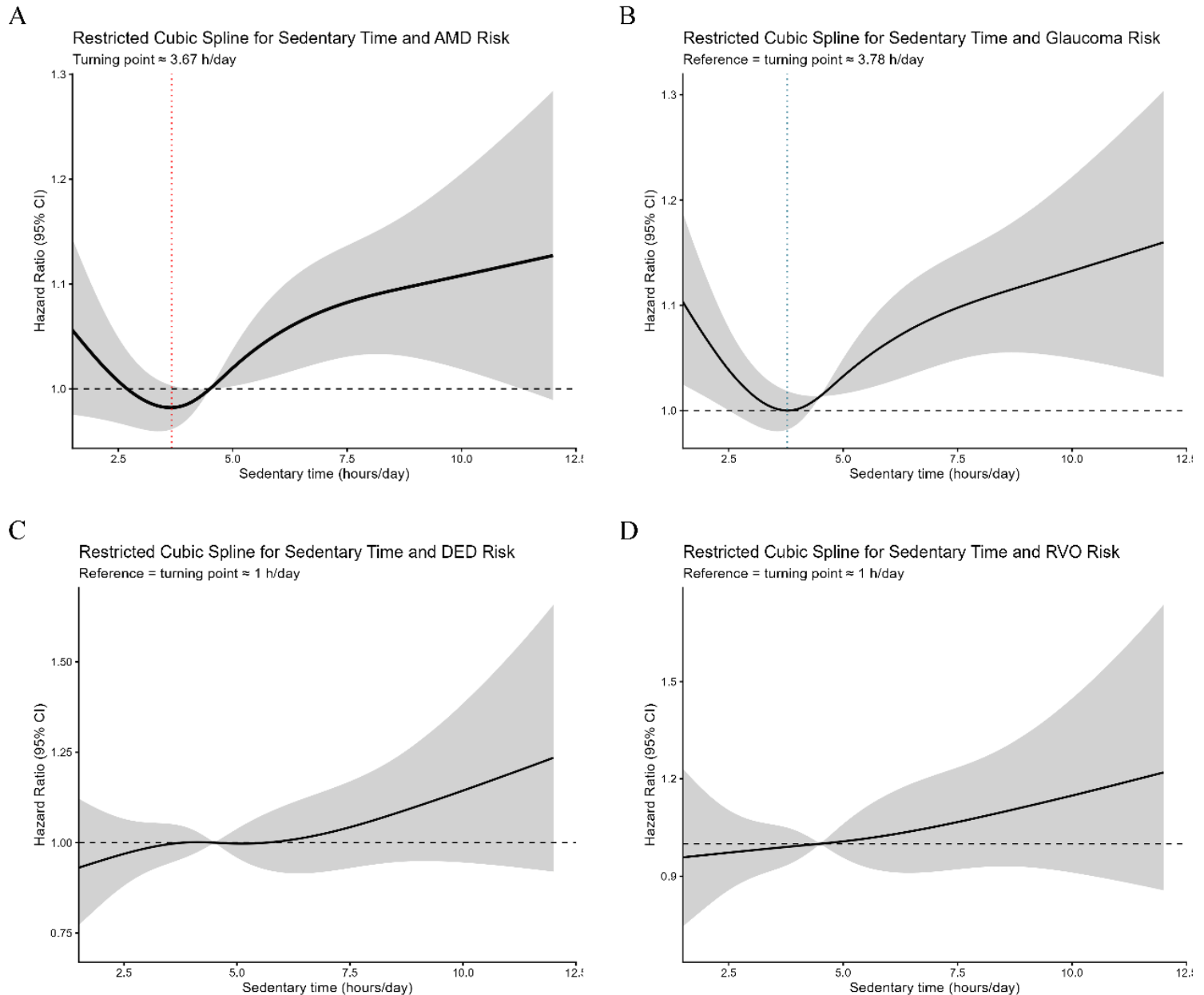


Figure 1

The dose–response associations of sedentary time with the risk of each eye disease.

Dose–response associations between AMD (A), glaucoma (B), DED (C), and RVO (D). Restricted cubic splines were constructed with three knots located at the 10th, 50th and 90th percentiles of sedentary

time. The models were adjusted for age, sex, ethnicity, education, household income, smoking status, alcohol consumption, body mass index, systolic blood pressure, HbA1c, and total cholesterol. CI, confidence interval.

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