Title: The association of objective and subjective vision impairment with self-reported time spent in sedentary behaviors in low- and middle-income countries

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ABSTRACT

Background: There is a scarcity of studies on the relationship between visual impairment (VI) and time spent in sedentary behaviour (SB), especially from low- and middle-income countries (LMICs). Thus, we investigated the association of objectively and subjectively measured VI with SB in adults aged ≥18 years across six LMICs.

Methods: Cross-sectional data from the WHO Study on global AGEing and adult health (SAGE) were analyzed. Objective and subjective visual acuity were measured. Information on self-reported SB was also collected. Multivariable multinomial logistic regression analysis was conducted to assess associations with time spent in SB as the outcome.

Results: The sample consisted of 42,489 individuals [mean age 43.8 (14.4) years; 50.1% females]. Only severe objective VI (vs. no VI) was significantly associated with ≥11 hours/day of SB (vs. <4 hours/day) (OR=4.50; 95%CI=1.57-12.92). Increasing severity of subjective VI was associated with greater odds for ≥8 hours/day of SB (vs. <4 hours/day) dose-dependently.

Conclusions: The present study identified an association of both objectively and subjectively measured VI with time spent in SB in adults residing in LMICs, with subjectively measured VI being a stronger predictor of time spent in SB. Targeted interventions to decrease SB especially in those who perceive themselves to have VI are needed in LMICs.

Key words: vision, low- and middle-income countries, epidemiology, measurement

INTRODUCTION

Sedentary behaviour can be defined here as any waking activity in a seated or reclining posture, such as watching TV, sitting for work, and sitting for school lessons. Sedentary behaviour (often measured sedentary time), has been shown to be detrimental to both physical and mental health [1,2], independent of physical activity levels [3]. However, global population levels of sedentary behaviour are generally high across the adult lifespan [4,5]. For example, objectively measured sedentary time has been reported as being 10.6hrs/day in adults [5], and >8.5hrs/day in most over 60 year olds [4].

Persons with disabilities tend to have high levels of sedentary behavior and understanding differences between the general population is important[6]. It is plausible to assume that those with disabilities, such as visual impairment, may exhibit very high levels of sedentary behaviour. This may be due to, for example, activity limitations in walking, and environmental barriers such as transport [7,8]. Indeed, a recent study including 6,001 adolescents and adults in the US found higher levels of sedentary time among female adults aged 20–49 years with objectively measured non-refractive visual impairment compared to those with normal vision [9]. To the best of our knowledge, no other study exists on the association between visual impairment and sedentary time. It is clear that more research is needed from diverse settings to gain a greater understanding on this topic, and to inform potential interventions, especially that more than 1 billion people have some type of vision impairment worldwide [10].

It is also important to note that a key limitation surrounding measurement of vision status in epidemiological studies is that vision status is generally self-reported and can thus introduce reporting bias, and this is particularly true for existing literature on visual impairment and physical activity (that sits at the opposing end of the energy expenditure continuum to

sedentary behaviour) [11–13]. To overcome this limitation, epidemiological investigation should attempt to measure vision using objective measures. However, it is also possible that differing associations may be observed between objectively measured and subjectively measure vision with a studied health outcome, as individual perception may influence behaviour independently of actual levels of visual impairment, and it is therefore of importance to include both measures.

Thus, the aim of the present study was to investigate the association of objectively and subjectively measured visual impairment with sedentary behaviour in adults aged ≥18 years across six LMICs. Studies from LMICs are important as the prevalence of both visual impairment and sedentary time are highest in such settings [14,15]. Furthermore, people with visual impairment in LMICs may be at particularly high risk of prolonged sedentary behaviour, as there is a paucity of human resources for refraction and optical services and a lack of access to refraction services in rural areas, while there may be more barriers for people with vision impairment to be active in LMICs than in high-income countries (e.g., transport). This study can potentially provide novel information to researchers and practitioners in LMICs on targeted interventions for sedentary behaviour reduction, and serve as a platform for future longitudinal studies.

METHODS

The survey

Data from the Study on Global AGEing and Adult Health (SAGE) [16] were analysed. These data are publicly available through http://www.who.int/healthinfo/sage/en/. This survey was undertaken in China, Ghana, India, Mexico, Russia, and South Africa between 2007 and

2010. Based on the World Bank classification at the time of the survey, all countries were LMICs.

Details of the survey methodology have been published elsewhere (Kowal et al., 2012). Briefly, in order to obtain nationally representative samples, a multistage clustered sampling design method was used. The sample consisted of adults aged ≥18 years with oversampling of those aged ≥50 years. Trained interviewers conducted face-to-face interviews using a standard questionnaire. The institutionalized were excluded from the sample. Standard translation procedures were undertaken to ensure comparability between countries. The survey response rates were: China 93%; Ghana 81%; India 68%; Mexico 53%; Russia 83%; and South Africa 75%. Sampling weights were constructed to adjust for the population structure as reported by the United Nations Statistical Division. Ethical approval was obtained from the WHO Ethical Review Committee and local ethics research review boards. Written informed consent was obtained from all participants.

Objective visual impairment

Visual acuity was measured using the tumbling ElogMAR chart for distance vision acuity separately for each eye. The participant was asked to be seated in a chair positioned so that the respondent's head is 4 meters from the eye chart. The interviewer was instructed to check that the vision charts are well lit and to make sure that the surface does not reflect glare. Furthermore, the respondent was instructed to use glasses or contact lenses if they usually wear them. We categorized far vision into the following levels of severity: no vision impairment (6/12 or better); mild vision impairment (6/18 or better but worse than 6/12); moderate vision impairment (6/60 or better but worse than 6/18); severe vision impairment (worse than 6/60) [10].

Subjective visual impairment

Subjective vision impairment was assessed with the question "In the last 30 days, how much difficulty did you have in seeing and recognizing an object or a person you know across the road (from a distance of about 20 meters)?" with answer options "none", "mild", "moderate", "severe", and "extreme/cannot do". This original 5-point scale was used in the analysis. Respondents were instructed to answer as when wearing glasses/contact lenses if used.

Sedentary time

In order to assess time spent in sedentary behaviours, participants were asked to state the total time they usually spend (expressed in minutes per day) sitting or reclining including at work, at home, getting to and from places, or with friends (e.g., sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television). This did not include time spent sleeping. The time spent sedentary was categorized into the recognized categories of <4, $4\leq8$, $8\leq11$, ≥11 hours/day [17].

Control variables

The control variables were selected based on past literature [9] and included age, sex, wealth quintiles based on country-specific income, highest level of education achieved (primary, secondary, tertiary), smoking (never, current, former), physical activity, obesity, and chronic physical conditions (angina, arthritis, diabetes, stroke). Levels of physical activity were assessed with the Global Physical Activity Questionnaire and were classified as low, moderate, and high based on conventional cut-offs [18]. A stadiometer and a routinely calibrated electronic weighting scale were used to measure height and weight respectively. Obesity was defined as body mass index $\geq30kg/m^2$. Arthritis, diabetes, and stroke were based on self-reported lifetime diagnosis. For angina, in addition to a self-reported diagnosis, a

symptom-based diagnosis based on the Rose questionnaire was also used [19]. Chronic physical conditions referred to having at least one of angina, arthritis, diabetes, or stroke.

Statistical analysis

The statistical analysis was performed with Stata 14.1 [20]. Multivariable multinomial logistic regression analysis was conducted to assess the association between objective and subjective far vision impairment (exposures) and time spent in sedentary behaviours (outcome), adjusting for sex, wealth, education, physical activity, smoking, obesity, chronic conditions, and country. Adjustment for country was done by including dummy variables for each country in the model as in previous SAGE publications [21,22]. All variables were included in the models as categorical variables except for age (continuous variable). The sample weighting and the complex study design were taken into account in all analyses. Results from the regression analyses are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The level of statistical significance was set at $P<0.05$.

RESULTS

The analytical sample consisted of 42,489 individuals aged ≥18 years (China n=14,813; Ghana n=5,110; India n=11,230; Mexico n=2,756; Russia n=4,355; South Africa n=4,225). The mean (SD) age was 43.8 (14.4) years, while 50.1% were females. The prevalence of sedentary behaviour in the overall population was: <4 hours/day 60.6%; 4-<8 hours/day 31.1%; 8-<11 hours/day 7.1%; ≥11 hours/day 1.2%. In terms of visual impairment, 8.4%, 7.0%, and 0.1% had mild, moderate, and severe objective visual impairment, while 15.3%, 7.2%, 3.3%, and 0.5% had mild, moderate, severe, and extreme subjective visual impairment. There was a large discrepancy between subjective and objective visual impairment (**Figure S1** of the Appendix). For example, among those with severe objective visual impairment (i.e.,

worse than 6/60), 30.5% claimed that they have no subjective visual impairment (i.e., no difficulty in seeing and recognizing an object or a person across the road). Sample characteristics are shown in **Table 1**. The prevalence of longer time spent in sedentary behaviour increased with increasing severity of objective visual impairment (**Figure 1**). Similar trends were found for subjective visual impairment (**Figure 2**). Those with longer time spent in sedentary behaviour were more likely to be older, poorer, engage in less physical activity, while they were also more likely to be obese and have chronic conditions. In terms of objective visual impairment, after adjustment for several potential confounders, only severe visual impairment (vs. no visual impairment) was significantly associated with ≥11 hours/day of sedentary behaviour (vs. <4 hours/day) with the OR (95%CI) being 4.50 (95%CI=1.57-12.92) (**Table 2**). For subjective visual impairment, increasing severity of visual impairment was associated with greater odds for ≥8 hours/day of sedentary behaviour (i.e., 8-<11 hours/day and ≥11 hours/day) when compared to <4 hours/day dose-dependently (**Table 3**). For example, for ≥11 hours/day vs. <4 hours/day of sedentary behaviour, compared to no subjective visual impairment, the OR (95%CI) of moderate, severe, and extreme visual impairment were 2.09 (1.29-3.39), 2.66 (1.56-4.53), and 3.80 (1.61-8.94), respectively.

DISCUSSION

The present study including 42,489 adults aged ≥18 years from six LMICs found that those with objectively measured severe visual impairment were significantly more likely to engage in ≥11 hours of sedentary behaviour per/day, when compared to those with no visual impairment. Interestingly, increasing severity of subjectively measured visual impairment was associated with greater odds of ≥8 hours a day of sedentary behaviour compared to those reporting less than 4 hours, in a dose dependent manner, suggesting that subjective visual

impairment is more commonly associated with time spent in sedentary behaviour than objective vision.

Collectively, these findings support and add to the only other study on visual impairment and time spent in sedentary behaviour conducted in the US [9]. Our findings support the previous study by demonstrating that an association between visual impairment and time spent in sedentary behaviour also exists in a large sample of LMICs. There are several plausible mechanisms that likely explain the association between visual impairment and longer time spent in sedentary behaviour. First, a growing body of literature has demonstrated that visual impairment is associated with lower levels of physical activity [11–13], and thus discretionary time is therefore likely to consist of sedentary behaviour. Considering this, barriers to physical activity participation among the visually impaired are therefore likely to be facilitators of sedentary behaviour. These barriers to physical activity and facilitators to sedentary time among those with visual impairment include limited access to recreational and athletic programmes, insufficient support to develop suitable and safe physical recreation skills and habits, activity limitations in walking, and environmental barriers such as transport and limited access to exercise equipment [12]. Second, sedentary behaviour per se may increase the likelihood of metabolic diseases [23,24], which in turn may lead to severe sight threatening issues if not controlled adequately. Finally, excessive sedentary time may reduce antioxidant enzyme activity and resistance to oxidative stress, which is thought to be one of the key components in the pathogenesis of age-related macular degeneration [25].

It is important to note that the present study found a stronger association between subjectively measured visual impairment with time spent in sedentary behaviour than objectively measured visual impairment. Moreover, this study found a large discrepancy

between objective and subjective visual impairment. For example, among those with severe objective visual impairment (i.e., worse than 6/60), 30.5% claimed that they have no subjective visual impairment. The discrepancy between objective and subjective visual impairment per se may be explained by factors such as one's norms; if respondents become accustomed to severe visual impairments for considerable amounts of time, they may not perceive that they have difficulty seeing, as they have adapted to the world around them. Furthermore, it is possible that people who have anxious personality traits or heighted stress sensitivity may be more likely to claim to have visual difficulty when in fact their vision is normal or almost normal based on objective measurement. Perceived stress and anxiety have both been previously linked to sedentary behaviour [26] via mechanisms such as displacing time spent fostering healthy interpersonal relationships or spent in physical activity [27], and thus, it is possible that psychopathology is implicated. Furthermore, previous literature has shown that those with poor mental health are more likely to over report physical health problems and are also more likely to exhibit greater time in sedentary behaviour [28,29]. This may also explain the reason why the association between subjective visual acuity and time spent in sedentary behaviour was particularly pronounced in our study. Our findings suggest that subjectively reported visual impairment is a key variable to be considered in sedentary behaviour research. However, clearly, further research using objectively measured sedentary behaviours are warranted, as is qualitative research to further understand these observed discrepancies.

Findings from the present study and that of previous literature suggest that interventions/ strategies are needed to reduce sedentary time in those with both objective and subjective visual impairment. This is in line with the WHO World report on vision [30] and the

resolution on ‘integrated, people-centered eye care, including preventable blindness and vision impairment’ adopted at 73rd World Health Assembly in 2020.

To achieve the greatest benefits for health among those who are visually impaired, it would be prudent to replace sedentary time with physical activity [31]. In order to achieve this, policy change will likely need to be focused at the societal level. This includes developing more accessible and inclusive environments and providing meaningful information about reductions in sedentary time and promotion of physical activity to adults with visual impairment and physical activity providers [8]. Further, optometrists/ophthalmologists, occupational therapists, physical therapists, social workers/case managers, and community health workers must coordinate care to ensure that individuals with visual impairments also receive treatment plans that involve physical activity promotion (e.g., safe and easy to use exercise equipment at home; exercise groups or classes for people with visual impairment).

The large representative sample across multiple LMICs and the investigation of objective and subjective visual impairment are clear strengths of the present study. However, findings must be interpreted considering the study limitations. First, given the cross-sectional nature of the study, causality or temporal associations cannot be established. Second, time spent in sedentary behaviour was self-reported potentially introducing self-reporting bias into the findings. Furthermore, as only one question was asked for subjective visual impairment, these results should be considered with caution. Future research should aim to measure objective sedentary behaviours and physical activity over time (passively though wearable devices) among people with objectively measured visual impairments, which may provide contextual and environmental data that can confirm or refute these results and can provide more data to be able to better inform targeted interventions.

Conclusions

For the first time, the present study identified an association between both objective and subjectively measured visual impairment and time spent in sedentary behaviours in adults residing in LMICs. Moreover, the present study suggests that subjectively measured visual impairment may be a stronger predictor of time spent in sedentary behaviour when compared to objectively measured visual impairment. Focusing on policy change at the societal levels may be an effective strategy to displace sedentary time with physical activity in those who are visually impaired, in order to improve both mental and physical health among this vulnerable population.

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All authors report no financial interests in this research.

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Tables and Figures

Table 1 Sample characteristics (overall and by time spent sedentary per day)

			Sedentary behaviour			
		Overall	0-<4h/day	4-<8h/day	8-<11h/day	≥11h/day
Age (years)	Mean (SD)	43.8 (14.4)	42.6 (13.1)	45.6 (15.3)	45.3 (16.6)	54.5 (22.2)
Sex	Male	49.9	50.4	48.9	49.6	48.1
	Female	50.1	49.6	51.1	50.4	51.9
Wealth	Poorest	14.9	15.7	13.9	11.2	25.7
	Poorer	17.8	19.1	15.7	15.4	22.0
	Middle	18.9	19.8	16.5	21.3	21.6
	Richer	21.2	21.8	21.4	16.1	14.7
	Richest	27.2	23.6	32.5	36.0	15.9
Education	Primary	43.2	47.2	38.1	33.3	33.1
	Secondary	46.4	43.8	50.0	50.7	56.9
	Tertiary	10.4	9.0	11.8	16.1	10.0
Physical activity	High	58.2	62.2	54.2	44.7	36.6
	Moderate	20.3	19.1	23.0	20.0	13.6
	Low	21.5	18.7	22.7	35.2	49.8
Smoking	Never	60.6	60.4	61.8	56.6	64.2
	Current	35.1	36.2	32.3	38.0	28.2
	Former	4.3	3.3	5.9	5.4	7.6
Obesity	No	93.1	94.1	92.1	90.2	82.7
	Yes	6.9	5.9	7.9	9.8	17.3
Chronic condition	No	79.2	81.4	77.1	72.1	60.8
	Yes	20.8	18.6	22.9	27.9	39.2

Abbreviation: SD Standard deviation
Data are column % unless otherwise stated.
Estimates are based on weighted sample.

Table 2 Association between objective visual impairment or covariates and sedentary behaviour (outcome) estimated by multinomial logistic regression

		Sedentary behaviour					
Characteristic		4-<8 vs. <4h/day		8-<11vs. <4h/day		≥11 vs. <4h/day	
Objective	None	1.00		1.00		1.00	
visual	Mild	0.95	[0.72,1.26]	1.02	[0.69,1.52]	0.71	[0.42,1.20]
impairment	Moderate	0.98	[0.76,1.26]	0.98	[0.68,1.41]	1.34	[0.63,2.86]
	Severe	0.69	[0.30,1.56]	1.17	[0.44,3.11]	4.50**	[1.57,12.92]
Age (years)		1.01***	[1.01,1.02]	1.01	[1.00,1.02]	1.03***	[1.01,1.05]
Sex	Male	1.00		1.00		1.00	
	Female	1.04	[0.88,1.23]	1.25	[0.90,1.73]	0.87	[0.51,1.49]
Wealth	Poorest	1.00		1.00		1.00	
	Poorer	0.90	[0.73,1.12]	1.03	[0.69,1.51]	0.95	[0.51,1.77]
	Middle	0.86	[0.69,1.07]	0.98	[0.61,1.57]	0.64	[0.30,1.36]
	Richer	0.93	[0.74,1.18]	0.76	[0.48,1.20]	0.62	[0.26,1.45]
	Richest	1.18	[0.92,1.51]	1.40	[0.86,2.29]	0.40*	[0.18,0.88]
Education	Primary	1.00		1.00		1.00	
	Secondary	1.11	[0.94,1.31]	1.08	[0.79,1.48]	1.38	[0.90,2.11]
	Tertiary	1.26	[0.91,1.73]	1.79*	[1.10,2.90]	2.08	[0.93,4.65]
Physical activity	High	1.00		1.00		1.00	
	Moderate	1.22	[0.99,1.50]	1.37	[0.96,1.94]	1.09	[0.55,2.13]
	Low	1.23*	[1.01,1.49]	2.24***	[1.61,3.12]	3.07***	[1.86,5.07]
Smoking	Never	1.00		1.00		1.00	
	Current	0.98	[0.82,1.17]	1.29	[0.93,1.79]	0.90	[0.49,1.66]
	Former	1.45	[0.89,2.37]	1.39	[0.79,2.44]	1.30	[0.58,2.89]
Obesity	No	1.00		1.00		1.00	
	Yes	1.12	[0.88,1.44]	1.16	[0.73,1.85]	1.90	[0.92,3.90]
Chronic condition	No	1.00		1.00		1.00	
	Yes	1.10	[0.92,1.32]	1.48	[0.97,2.25]	1.33	[0.73,2.42]

Data are odds ratio [95% confidence interval].
Model is mutually adjusted for all variables in the Table and country.
Categories of objective vision impairment referred to the following: no vision impairment (6/12 or better); mild vision impairment = 6/18 or better but worse than 6/12; moderate vision impairment = 6/60 or better but worse than 6/18; severe vision impairment = worse than 6/60.
* $p<0.05$, *** $p<0.001$

Table 3 Association between subjective visual impairment or covariates and sedentary behaviour (outcome) estimated by multinomial logistic regression

		Sedentary behaviour					
Characteristic		4-<8h/day vs. <4h/day		8-<11h/day vs. <4h/day		≥11h/day vs. <4h/day	
Subjective	None	1.00		1.00		1.00	
visual	Mild	0.94	[0.77,1.13]	0.97	[0.70,1.34]	1.45	[0.72,2.93]
impairment	Moderate	0.93	[0.76,1.15]	1.29	[0.86,1.94]	2.09**	[1.29,3.39]
	Severe	1.30	[0.99,1.72]	2.55***	[1.56,4.14]	2.66***	[1.56,4.53]
	Extreme	1.71	[0.97,3.01]	5.36***	[3.18,9.02]	3.80**	[1.61,8.94]
Age (years)		1.01***	[1.01,1.02]	1.00	[0.99,1.01]	1.03**	[1.01,1.04]
Sex	Male	1.00		1.00		1.00	
	Female	1.03	[0.87,1.22]	1.18	[0.87,1.61]	0.86	[0.51,1.43]
Wealth	Poorest	1.00		1.00		1.00	
	Poorer	0.89	[0.72,1.10]	1.14	[0.78,1.68]	0.93	[0.52,1.66]
	Middle	0.84	[0.67,1.05]	1.10	[0.70,1.73]	0.66	[0.33,1.32]
	Richer	0.90	[0.71,1.13]	0.82	[0.52,1.27]	0.57	[0.26,1.26]
	Richest	1.18	[0.92,1.52]	1.55	[0.97,2.49]	0.38**	[0.18,0.79]
Education	Primary	1.00		1.00		1.00	
	Secondary	1.10	[0.94,1.29]	1.05	[0.76,1.46]	1.40	[0.92,2.12]
	Tertiary	1.23	[0.89,1.69]	1.69*	[1.05,2.72]	2.18*	[1.04,4.55]
Physical activity	High	1.00		1.00		1.00	
	Moderate	1.25*	[1.02,1.53]	1.40	[0.99,1.98]	1.12	[0.60,2.11]
	Low	1.24*	[1.02,1.50]	2.44***	[1.77,3.38]	2.94***	[1.83,4.74]
Smoking	Never	1.00		1.00		1.00	
	Current	0.99	[0.83,1.18]	1.27	[0.92,1.77]	0.87	[0.49,1.54]
	Former	1.42	[0.88,2.30]	1.35	[0.81,2.26]	1.26	[0.61,2.58]
Obesity	No	1.00		1.00		1.00	
	Yes	1.11	[0.84,1.46]	1.29	[0.79,2.11]	1.94*	[1.01,3.73]
Chronic condition	No	1.00		1.00		1.00	
	Yes	1.13	[0.95,1.34]	1.54*	[1.04,2.27]	1.39	[0.82,2.37]

Data are odds ratio [95% confidence interval].
Model is mutually adjusted for all variables in the Table and country.
Subjective vision impairment referred to the answer to the question "In the last 30 days, how much difficulty did you have in seeing and recognizing an object or a person you know across the road (from a distance of about 20 meters)?"
* p<0.05, ** p<0.01, *** p<0.001

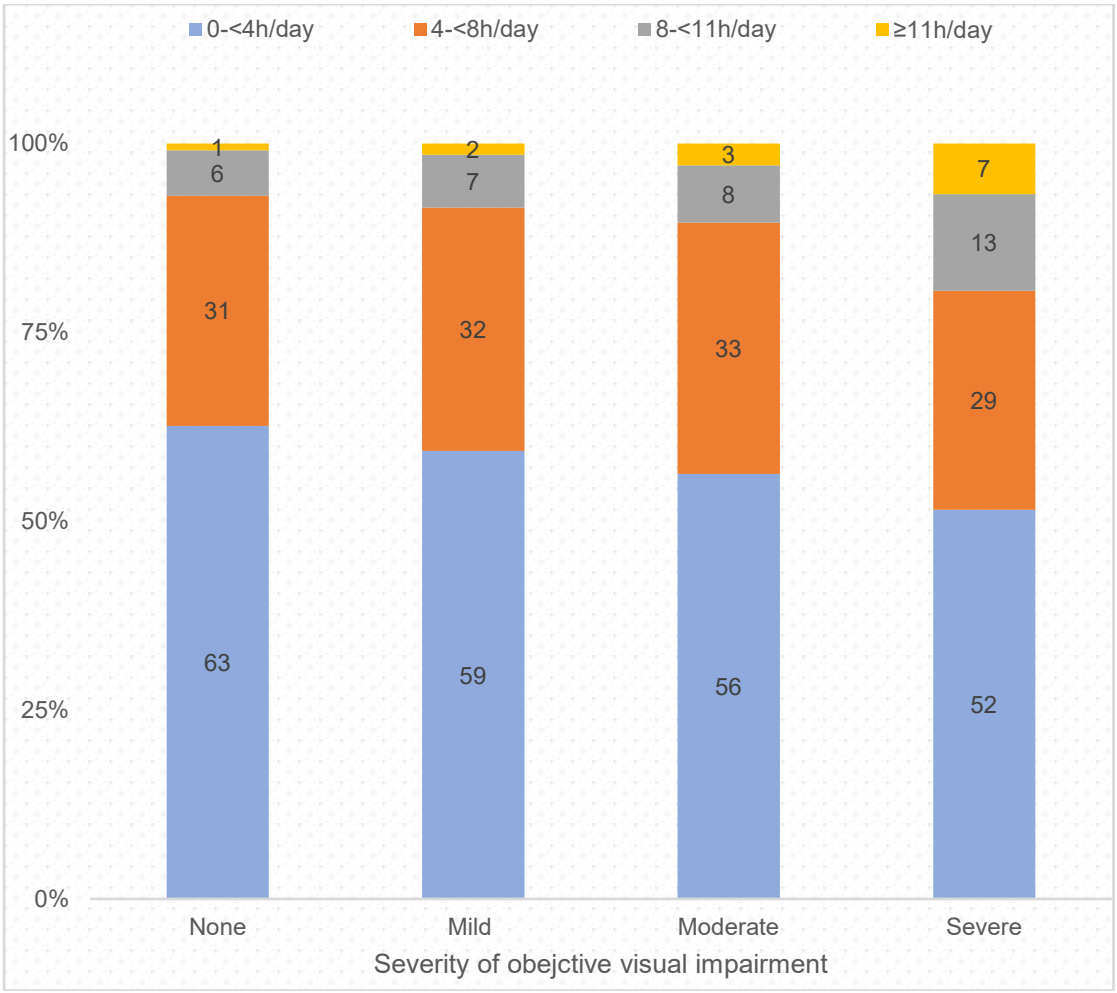

Figure 1 Distribution of different levels of sedentary behaviour by severity of objective visual impairment

Categories of objective vision impairment referred to the following: no vision impairment (6/12 or better); mild vision impairment = 6/18 or better but worse than 6/12; moderate vision impairment = 6/60 or better but worse than 6/18; severe vision impairment = worse than 6/60.

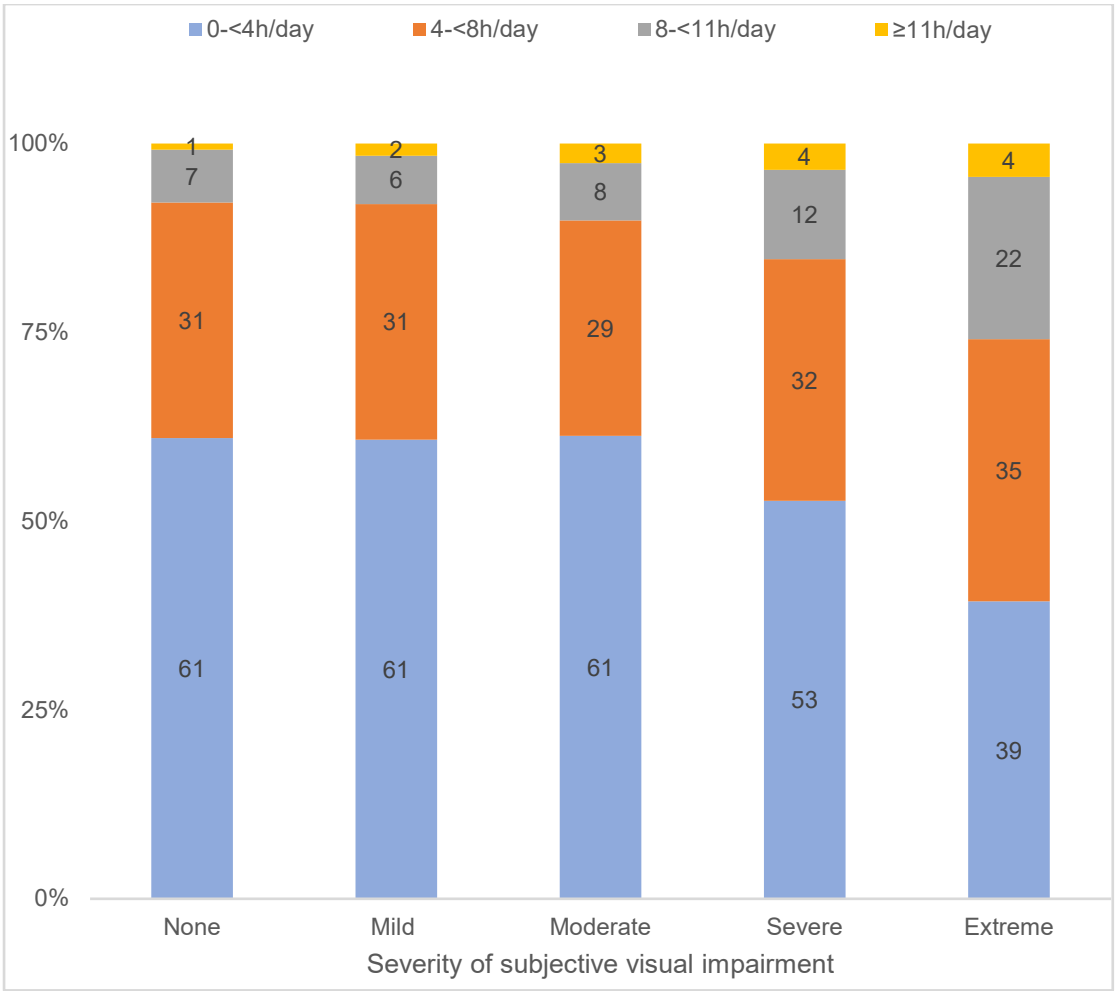

Figure 2 Distribution of different levels of sedentary behaviour by severity of subjective visual impairment

Subjective vision impairment referred to the answer to the question "In the last 30 days, how much difficulty did you have in seeing and recognizing an object or a person you know across the road (from a distance of about 20 meters)?"

APPENDIX

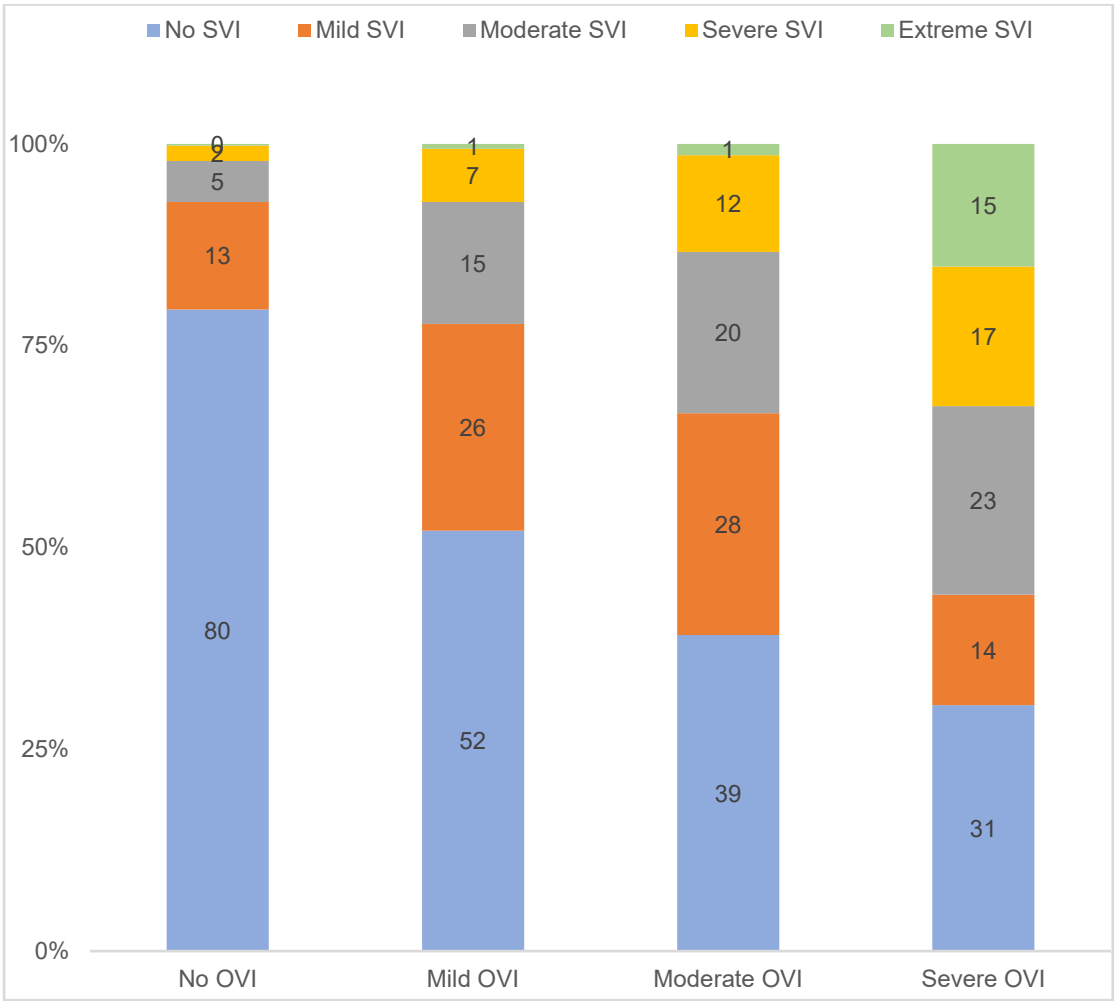

Figure S1 Distribution of severity of subjective visual impairment by different levels of objective visual impairment

Abbreviation: OVI Objective visual impairment; SVI Subjective visual impairment

Categories of objective vision impairment referred to the following: no vision impairment (6/12 or better); mild vision impairment = 6/18 or better but worse than 6/12; moderate vision impairment = 6/60 or better but worse than 6/18; severe vision impairment = worse than 6/60.

Subjective vision impairment referred to the answer to the question "In the last 30 days, how much difficulty did you have in seeing and recognizing an object or a person you know across the road (from a distance of about 20 meters)?"