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Visual acuity thresholds associated with activity limitations in the elderly. The Pathologies Oculaires Liées à l'Age study

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ABSTRACT.
Purpose: **Activity limitations, which induce loss of autonomy in the elderly, are a major public health problem. We investigated the associations between objectively determined visual impairments and activity limitations and assessed the visual acuity thresholds associated with these restrictions.**
Methods: **The study sample consisted of 1887 people aged 63 years and over from a population-based cohort. Moderate to severe visual impairment was defined as presenting visual acuity lower than 20/70, according to the World Health Organization (WHO) definition. In addition, we studied mild visual impairment, defined as visual acuity [20/70–20/40]. Multivariate logistic regressions were used to estimate the associations between vision and instrumental activities of daily living (IADL) limitations. Using receiver-operating characteristic (ROC) curves, we identified visual acuity thresholds that maximized the Youden index ([sensitivity + specificity]−1) for predicting IADL limitations.**
Results: **After adjustment for potential confounders, moderate to severe visual impairment and mild visual impairment were strongly associated with IADL limitations (odds ratio [OR] = 3.49; 95% confidence interval [CI] = 1.93, 6.32 and OR = 1.77; 95% CI = 1.07, 2.91, respectively). Visual acuity was a strong predictor of IADL limitations, with an area under the ROC curve of 0.72 (95% CI = 0.68, 0.76). The best discrimination between subjects with or without IADL limitations (global, physical and cognitive) was obtained for visual acuities around 20/40–20/50.**
Conclusion: **This study confirms major increased risk for IADL limitations in subjects with moderate to severe visual impairment. In addition, it suggests that milder visual impairments (in particular below 20/40) may also be related to an increased risk for IADL limitations and should be considered for early medical intervention, before the decline of the subject autonomy.**

Key words: activities of daily living – autonomy – elderly, public health – visual acuity threshold

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Introduction

The rise in the average life span in western countries has coincided with a reduction in the lethality of most chronic illnesses. The great majority of older adults are living independently at home; however, difficulties in performing daily tasks develop with age (Fulton et al. 1989).

Assessment of health conditions associated with activity limitations, particularly those which may be avoidable or treatable, is therefore a primary concern of public health policy (Murray & Lopez 1997). Furthermore, community-based intervention programs have been shown to improve functional outcomes and reduce the rate of nursing home admissions in older people (Stuck et al. 2002; Huss et al. 2008).

It is well-established that the disablement process is highly multifactorial, with several chronic and acute conditions, potentially inducing psychological and physical deficiencies that lead to difficulties in performing daily tasks (Verbrugge & Jette 1994). Visual impairment is one of the major deficiencies leading to activity limitations. In the Medical Research Council Cognitive Function and Ageing Study, along with cognitive impairment, arthritis and stroke, problems with vision were found to have a major impact on elderly population autonomy (Spiers et al. 2005).

Activities of daily living (ADL) refer to daily self-care tasks including showering, dressing, eating, etc. Instrumental activities of daily living (IADL) are not necessary for fundamental functioning, but they let an individual live independently in a community: taking medications, managing money, use of telephone, etc.

Visual acuity thresholds correlated with IADL restrictions may be instrumental in the decision to initiate clinical intervention, before the apparition of activity limitations and the subsequent loss of autonomy.

This study assesses the association between visual impairment and activity limitations in a community-dwelling elderly cohort in which visual acuity was measured by ophthalmologists. The visual acuity thresholds associated with activity limitations were assessed based on receiver-operating characteristic (ROC) curves.

Patients and Methods

Study population

The Pathologies Oculaires Liées à l'Age (POLA) study is a prospective study, aimed at identifying the risk factors of age-related eye diseases. The methods of this study have been published elsewhere (Delcourt et al. 1998). The present cross-sectional study focused on the 1947 people who completed the 3-year follow-up visit (1998–2000), which included visual examinations in a mobile unit, equipped with ophthalmologic devices, a standardized questionnaire on medical history and lifestyle habits and the assessment of IADL limitations (Lawton & Brody 1969). This research was approved by the ethical committee of the University Hospital of Montpellier, France, and written informed consent was obtained from each participant.

Measurement of activity limitations

Participants were classified as having IADL limitations if they were unable to perform at least one of the eight activities of the Lawton scale without assistance: housekeeping, doing laundry, shopping, food preparation, using transportation, taking medication, handling finances or using the telephone (Lawton & Brody 1969).

Two separate binary variables, assessing the cognitive and physical domains of the IADL activities, were also created (Thomas et al. 1998). The cognitive domains of the IADL scale included taking medication, handling finances and using the telephone, while the physical ones comprised shopping and using transportation.

Visual acuity

Three ophthalmologists performed the eye examinations, which included a recording of ophthalmologic history and a measurement of distance visual acuity in each eye, with the usual optical correction (presenting visual acuity).

As shown in Table 1, distance visual acuity was assessed with the Snellen decimal chart and expressed as the logarithm of the minimum angle of resolution (logMAR). 'Moderate to severe visual impairment' (including blindness) was defined according to the World Health Organization (WHO) criteria (presenting distance visual acuity worse than 0.5 logMAR [<20/70] in the better-seeing eye (World Health Organization, International Statistical Classification of Diseases & Health Related Problems 2007). Due to the scarcity of individuals qualifying for each of the WHO visual impairment subgroups (121 moderate visual impairment [20/200–20/70], 0 with severe visual impairment [20/400–20/200] vision and 14 with blindness [<20/400]), all of these participants were classified as being part of the 'moderate to severe group'. The 'mild visual impairment group' included the participants who failed to achieve the minimum vision standards for driving, a level that has been suggested to represent the economic impact of visual impairment in the industrialized world (Rahi et al. 2009). It is defined by a range of 0.3–0.5 logMAR (20/40–20/70) units in the better-seeing eye. The 'unilateral visual loss group' included participants with visual acuities of lower than 0.3 logMAR for one eye and normal for the other eye (i.e. between 0 and 0.3 logMAR [20/40–20/20]). The remaining participants were classified as being part of the 'normal group' (0.3 logMAR units in each eye).

Statistical analysis

The chi-square test was used to compare the participant's characteristics according to the IADL limitations. Age- and sex-adjusted odds ratios (ORs) were obtained by logistic regression, with the IADL limitations as the dependent variable. All covariates associated at the 20% level ($p < 0.20$) were included in the multivariate logistic model as potential confounders. To assess the robustness of findings, a *post hoc* statistical power was computed. For an alpha risk at 5% with a power of 80%, the present analysis could detect an OR of 2.0 for unilateral visual loss, an OR of 2.1 for mild visual impairment and an OR of 2.7 for moderate to severe visual impairment.

Visual acuity thresholds were assessed using the better-seeing eye visual acuity for global IADL as well as for physical and cognitive domains of IADL limitations. A ROC curve was plotted to identify a cut-off value of visual acuity that correlated with the presence of IADL limitations (Halpern et al. 1996). True positives were subjects with visual impairment (according to each chosen threshold) and IADL limitations and true negatives were subjects without visual impairment and without IADL limitations. The best possible visual acuity threshold

Table 1. Number and percentage of subjects having distance visual impairment.

	Presenting distance visual acuity	No. (%)
Normal bilateral	20/40–20/20 units in each eye (0.0–0.3 logMAR)	726 (38.5)
Unilateral visual loss	20/40–20/20 in one eye and <20/40 in the other (0.0–0.3 logMAR in 1 eye and >0.3 logMAR in the other)	550 (29.1)
Mild visual impairment	20/70–20/40 in the better-seeing eye (0.31–0.5 logMAR)	470 (24.9)
Moderate to severe visual impairment	<20/70 in both eyes (>0.5 logMAR)	141 (7.5)
Total		1887 (100)

logMAR= logarithm of the minimum angle of resolution.

was determined using the highest Youden index ([specificity + sensibility]−1) (Greenhouse et al. 1950). The analyses were performed using SAS software (version 9.2, SAS Institute, Cary, NC, USA).

Results

Study sample

Among 1947 participants at the 3-year follow-up, 60 (3.0%) were excluded due to missing data (36 for ophthalmological data, 16 for interview data and 8 for IADL data). Therefore, the statistical analyses involved 1887 participants (804 men and 1083 women), among whom 10.3% (195) had IADL limitations. The median age (interquartile range) was 72.3 years (68.1–77.0).

When the included individuals were compared with the 60 excluded participants, the only significant differences were the use of antidepressant drugs (16.7% in excluded participants versus 6.8%, $p < 0.004$) and alcohol consumption (31.0% teetotallers in excluded participants versus 21.2%, $p = 0.02$).

As presented in Table 1, of the included participants, 38.5% had normal presenting vision in both eyes, 29.1% normal vision in only one eye, 24.9% a mild visual impairment and 7.5% moderate to severe visual impairment in both eyes.

IADL limitations and sociodemographic and clinical factors

Table 2 shows the sociodemographic and clinical characteristics of participants, grouped by the presence or absence of IADL limitations. The proportion of participants with IADL limitations increased with age (4.3% for 63–74 year olds and 21.7% for participants aged 75 years or over), and women were more likely to report difficulties (13.9% versus 5.6% of men). The study of the association between each potential confounding factor and IADL showed a significantly decreased risk of activity limitations for participants living alone (OR = 0.61; 95% confidence interval [CI] = 0.43, 0.89). An increased risk was observed for current smokers (OR = 2.73; 95% CI = 1.46, 5.12), alcohol teetotallers (OR = 1.77; 95% CI = 1.23, 2.56), participants with cardiovascular history (OR = 2.12; 95% CI = 1.43, 3.16) and those using antidepressant drugs (OR = 2.93; 95% CI = 1.82, 4.73).

IADL limitations and visual function

The crude and adjusted associations between visual acuity and IADL limitations are given in Table 3. Only 15.4% of subjects with IADL limitations had normal bilateral presenting vision, versus 41.1% of subjects without IADL limitations. The difference was in the same direction for unilateral visual loss, although weaker (21.5% versus 30.0%). In contrast, mild visual impairment and moderate to severe visual impairment were much more frequent in subjects with IADL limitations (39.0% versus 23.3%, and 24.1% versus 5.6%, respectively). Participants with impaired vision, except the unilateral loss group, were more likely to be limited in IADL, and the odds increased with worsening visual

Table 2. Baseline characteristics of participants according to activity limitations.

Characteristics	Participants without IADL limitations $n = 1692$ No. (%)	Participants with IADL limitations $n = 195$ No. (%)	χ^2 test p Value	Age- and sex-adjusted odds ratios	
				OR	95% confidence intervals
Female	933 (55.1)	150 (76.9)	<0.0001		
Age (years)					
63–74	1180 (69.7)	53 (27.2)	<0.0001		
≥75	512 (30.3)	142 (72.8)			
Living alone	491 (29.0)	78 (40.0)	0.002	0.61	0.43; 0.89
High education level	136 (8.0)	9 (4.6)	0.09	0.79	0.37; 1.65
Diabetes	136 (8.0)	19 (9.7)	0.41	1.41	0.80; 2.47
Hypertension	781 (46.2)	90 (46.2)	0.99	0.84	0.61; 1.17
Smoking					
Never smoker	1005 (59.4)	138 (70.8)	0.001	1	
Former smoker	564 (33.3)	40 (20.5)		1.11	0.69; 1.77
Current smoker	123 (7.3)	17 (8.7)		2.73	1.46; 5.12
Alcohol					
Moderate consumption	983 (58.1)	105 (53.8)	<0.0001	1	
Excessive consumption	378 (22.3)	21 (10.8)		0.80	0.48; 1.36
Teetotallers	331 (19.6)	69 (35.4)		1.77	1.23; 2.56
BMI					
Normal	591 (34.9)	93 (47.7)	<0.0001	1	
Overweighted	786 (46.5)	63 (32.3)		0.61	0.42; 0.89
Obese	315 (18.6)	39 (20.0)		0.93	0.61; 1.44
Cardiovascular disease	233 (13.8)	55 (28.2)	<0.0001	2.12	1.43; 3.16
Cerebrovascular disease	73 (4.3)	15 (7.7)	0.03	1.62	0.84; 3.12
Respiratory insufficiency	38 (2.3)	6 (3.1)	0.46	1.60	0.61; 4.26
Use of antidepressant drugs	96 (5.7)	33 (16.9)	<0.0001	2.93	1.82; 4.73
Orthopaedic impairment in the last 3 years	144 (8.5)	25 (12.8)	0.05	1.36	0.83; 2.24
Hospitalizations during the last 12 months	276 (16.3)	43 (22.0)	0.06	1.43	0.96; 2.12
Hearing impairment	487 (28.8)	80 (41.0)	0.0001	1.23	0.88; 1.73

IADL= instrumental activities of daily living.

Table 3. Associations between presenting visual impairment and activity limitations.

	Participants without IADL limitations No. (%)	Participants with IADL limitations No. (%)	χ^2 test p Value	Age- and gender-adjusted OR		Multivariate model*	
				OR	95% CI	OR	95% CI
Global IADL	*N* = 1692 (89.7)	*N* = 195 (10.3)					
Presenting visual acuity							
Normal, bilateral	696 (41.1)	30 (15.4)	<0.0001	1		1	
Unilateral visual loss	508 (30.0)	42 (21.5)		1.28	0.78; 2.13	1.04	0.61; 1.75
Mild visual impairment	394 (23.3)	76 (39.0)		1.97	1.21; 3.18	1.77	1.07; 2.91
Moderate to severe visual impairment	94 (5.6)	47 (24.1)		3.86	2.18; 6.83	3.49	1.93; 6.32
Physical domains of the IADL	*N* = 1721 (91.2)	*N* = 166 (8.8)					
Presenting visual acuity							
Normal, bilateral	703 (40.9)	23 (13.8)	<0.0001	1		1	
Unilateral visual loss	516 (30.0)	34 (20.5)		1.30	0.74; 2.30	1.02	0.57; 1.84
Mild visual impairment	403 (23.4)	67 (40.4)		2.14	1.25; 3.64	1.88	1.08; 3.26
Moderate to severe visual impairment	99 (5.7)	42 (25.3)		3.99	2.15; 7.45	3.54	1.85; 6.75
Cognitive domains of the IADL	*N* = 1817 (96.3)	*N* = 70 (3.7)					
Presenting visual acuity							
Normal, bilateral	717 (39.5)	9 (12.8)	<0.0001	1		1	
Unilateral visual loss	536 (29.5)	14 (20.0)		1.63	0.69; 3.83	1.30	0.54; 3.13
Mild visual impairment	447 (24.6)	23 (32.9)		2.39	1.05; 5.45	1.92	0.82; 4.50
Moderate to severe visual impairment	117 (6.4)	24 (34.3)		7.82	3.30; 18.54	7.20	2.96; 17.52

IADL= instrumental activities of daily living; OR= odds ratio; CI= confidence interval.
*Adjusted for age, sex, living alone, smoking, alcohol intake, body mass index, cardiovascular disease, cerebrovascular disease, use of antidepressant drugs, hearing impairment, hospitalizations during the last 12 months and orthopaedic impairment in the last 3 years.

impairment. The age- and sex-adjusted analyses for participants with moderate to severe visual impairment have found over three times more IADL limitations than those with normal visual acuity in both eyes (OR = 3.86; 95% CI = 2.18, 6.83). Participants with mild visual impairment also had an increased odds of having IADL limitations (OR = 1.97; 95% CI = 1.21, 3.18). Multivariate adjustments did not significantly influence OR for participants with moderate to severe visual impairment (OR = 3.49; 95% CI = 1.93, 6.32) or for participants with a mild visual impairment (OR = 1.77; 95% CI = 1.07, 2.91). A trend was found for a stronger association between moderate to severe visual impairment and the cognitive domains of IADL (OR = 7.20; 95% CI = 2.96, 17.52) than the physical domains of IADL (OR = 3.54; 95% CI = 1.85, 6.75). No significant interactions with age, diabetes or cerebrovascular disease were found.

Visual acuity thresholds associated with IADL limitations

As shown in Fig. 1, visual acuity of the better-seeing eye was a strong predictor of IADL limitations, with an area under the ROC curve of 0.72 (95% CI = 0.68, 0.76) for global IADL (Fig. 1A), 0.74 (95% CI = 0.69, 0.78) for physical IADL (Fig. 1B) and 0.74 (95% CI = 0.67, 0.81) for cognitive IADL (Fig. 1C). Table 4 presents different threshold values for global, physical and cognitive IADL, respectively. According to the maximum of the Youden index, the best thresholds for discrimination between subjects with or without IADL limitations were around 20/40–20/50 for global, cognitive and physical IADLs.

Discussion

This study among non-institutionalized elderly people confirmed the independent association between limitations in IADL and visual impairment, for moderate to severe visual impairment (as defined by WHO) but also for milder visual impairment (in particular below 20/40).

In the present study, we observed particularly strong associations of moderate to severe visual impairment with global IADL limitations, as well as physical and cognitive activity limitations, with fully adjusted ORs ranging from 3.49 to 7.20. We also found significant associations of mild visual impairment with global or physical IADL limitations.

Although the prevalence of mild and moderate to severe visual impairments were high in the present study (24.9% and 7.5%, respectively), similar prevalence rates were observed in a British study performed in the same time period (12% of moderate of severe visual impairment in subjects aged 75 years or more) (Evans et al. 2002). Other European studies usually have used best-corrected visual acuity and therefore cannot be compared with the present study (Klaver et al. 1998; Gunnlaugsdottir et al. 2008; Seland et al. 2011). In the American NHANES study, performed in 1999–2002, prevalence of visual impairment (presenting visual acuity below 20/40) was 8.8% in subjects aged 60 years or more, which is much lower than the present study (Vitale et al. 2006).

It is interesting to note that participants with unilateral vision loss had no increased limitations in IADL, when compared to those with normal bilateral vision. This may be explained by the possibility of successfully performing all of the IADL tasks when using only one eye with a normal visual acuity. Furthermore, in agreement with our results, among 2520 community-dwelling residents aged 65–84 years, monocular acuity in the better eye and binocular acuity were found to be equally good predictors of self-reported vision disability (Rubin et al. 2000). This observation therefore

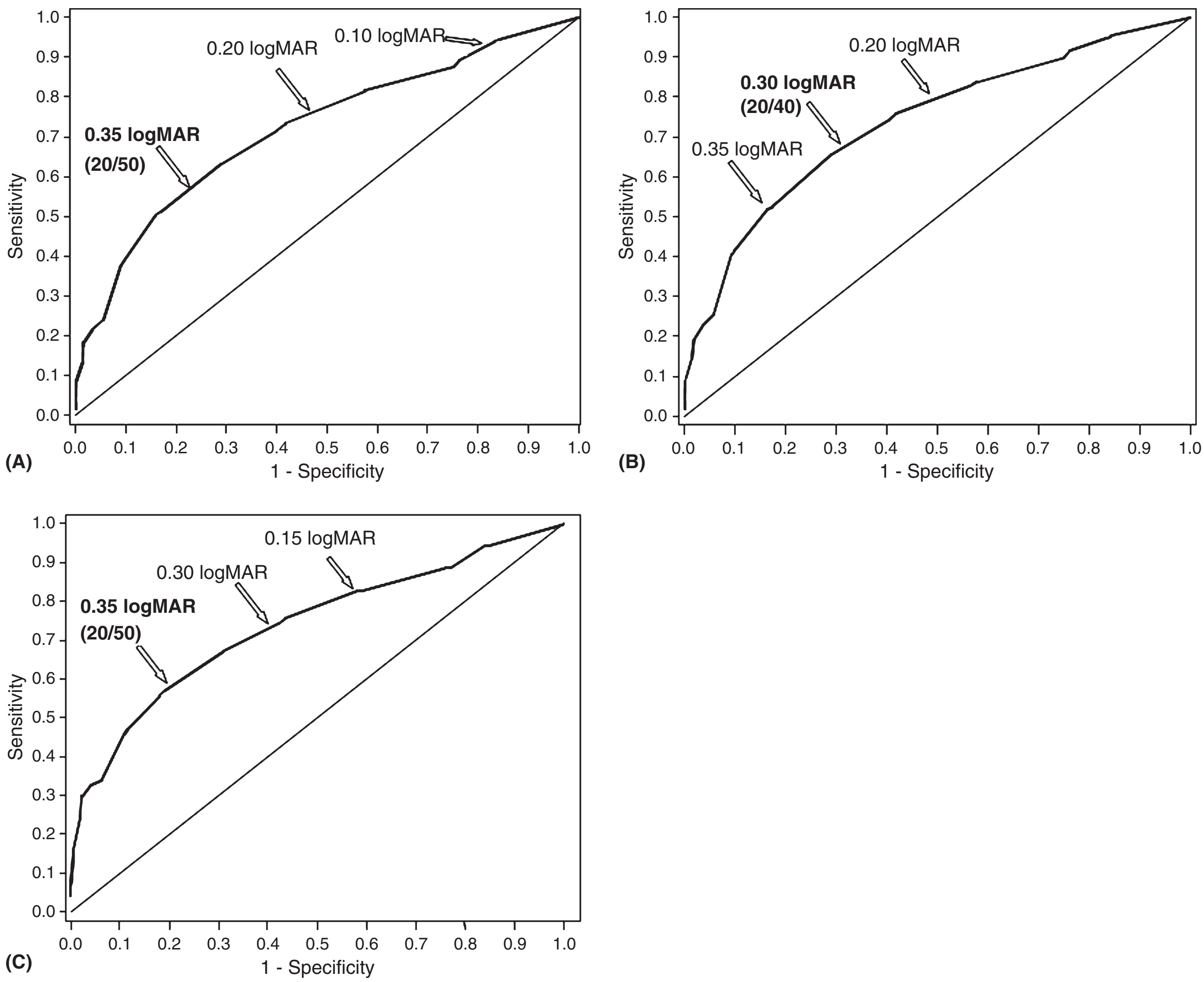

Fig. 1. Receiver-operating characteristic (ROC) curves of mean logMAR visual acuity levels for the prediction of activity limitations in 1887 elderly people. (A) shows the ROC curve for global activity limitations, (B) shows the ROC curve for a physical activity limitation, and (C) shows the ROC curve for cognitive activity limitations. Highest Youden index are in bold.

Table 4. Youden index* of better-seeing eye visual acuity to identify an activity limitations.

Visual acuity (LogMAR)	Youden index for global activity limitations	Youden index for physical activity limitations	Youden index for cognitive activity limitations
20/20 (0.00)	0.0	0.0	0.0
20/25 (0.10)	12.5	14.6	12.6
20/32 (0.20)	31.7	34.0	32.0
20/40 (0.30)	**34.2**	**36.5**	**36.1**
20/50 (0.35)	**34.4**	**35.0**	**38.1**
20/63 (0.50)	28.7	30.9	34.8
20/80 (0.60)	18.5	19.5	27.8
20/100 (0.70)	18.2	19.3	28.7
20/125 (0.80)	15.8	17.3	27.5
20/200 (1.00)	11.9	0.0	22.5

Highest Youden index are in bold.
* The best possible visual acuity threshold was determined using the highest Youden index ([specificity + sensibility]−1).

indicates the importance of visual rehabilitation, in relation to its impact on activity restriction in the elderly, because even an improvement in monocular acuity may have a positive effect.

Assessment of thresholds of visual acuity, best associated with IADL limitations, provides information that could be used as a basis for clinical decisions regarding patient treatment and medical intervention. Receiver-operating characteristic curve analyses confirmed that visual acuity is a strong predictor of IADL limitations, with an area under the ROC curve of 0.72. The best discrimination between subjects with or without IADL limitations (global, physical and cognitive) was obtained for visual acuities around 20/40–20/50, according to the Youden index. This suggests that visual decline is leading to physical prior to cognitive IADL limitations. We do not suggest that this threshold of visual acuity should be used as a gold standard in clinical or surgical settings. The 20/40 standard is the criterion most widely used for safe driving (Colenbrander & De Laey 2006), and other aspects of visual function such as contrast sensitivity and visual field are important for driving (Sandlin et al. 2013). The present analysis showed that when visual acuity is around 20/40 and 20/50, the person is more likely to have an IADL limitation. Establishing which levels of visual impairments are associated with the loss of autonomy may be of interest, particularly for ophthalmologists and geriatricians. For instance, the visual threshold of 20/40 at which the decision is taken to perform cataract surgery is based on observational studies (Taylor et al. 2006) or series of audit (Setty et al. 2000), but is not related to the ability of the patient to perform daily tasks. However, the consequence on daily activity of any loss to visual acuity should remain the main feature to consider before any cataract procedure. While the demand for surgical intervention at an early stage has increased during the last decade, there remains a cohort of patients, with cataracts, yielding visions of 20/50 or worse, which should be treated before the subsequent onset of activity limitations. The present study also suggests that the current WHO definition of visual impairment excludes many subjects with actual difficulties in daily living activities due to visual functioning. Thus, the current WHO definition of visual impairment probably leads to underestimations of the frequency of visual problems in the population.

According to the WHO definition (World Health Organization, International Statistical Classification of Diseases & Health Related Problems 2007), in the present study, visual impairment was assessed using presenting visual acuity. Indeed, best-corrected visual acuity overlooks a large proportion of subjects with visual impairment due to uncorrected refractive errors, with substantial functional impact. Visual impairment may thus be due to functional causes including uncorrected refractive errors (myopia, hyperopia, astigmatism and presbyopia) and/or to organic causes including cataracts, glaucoma, age-related macular degeneration. Consistent with other studies (Vitale et al. 2006; Resnikoff et al. 2008), in the POLA sample, uncorrected refractive error affected 38.5% of participants and was a significant cause of visual impairment. We suggested that it has significant functional consequences and that IADL limitations could be prevented in one-fifth of this population with the simple use of their best achieved optical correction (Daien et al. 2011). Besides, many efficient therapies, capable of maintaining or restoring vision, are available for all major eye diseases and may help prevent functional limitations (Resnikoff et al. 2008).

According to the 2009 American Academy of Ophthalmology recommendations, it is important for elderly people (aged 65 years or over) to have eye examinations on a regular basis, every 1–2 years. A significant effort should be made to increase ophthalmic screening of the elderly.

Limitations

Our study was cross-sectional, so the chronology of events could not be determined. Although it seems intuitive that visual impairment directly affects IADL tasks, we were unable to analyse the temporal evolution of the association between visual impairment and activity limitations. In particular, the effects of adopted compensatory strategies in performing IADL tasks were impossible to quantify. However, previous studies have shown an increase in the quality of life and a decrease in depression rates after improvement of vision through optical correction or cataract surgery (Owsley et al. 2007a, b). The proportion of patients suffering visual impairments may have changed since the 2000s (in particular because of higher cataract surgery rates), but this is unlikely to have affected the associations between visual acuity and IADL.

The POLA ophthalmic examination included cataract and age-related macular degeneration, but no information was recorded about other ocular conditions. In the present study, we were unable to determine the relative part of organic and functional causes in relation with activity limitations.

Data assessing ADL were not available in the current study, and we only used IADL to assess activity dependency of participants. However, IADL limitations generally require a greater complexity of neuropsychological organization and consequently are more likely to be vulnerable to the early effects of functional visual decline in the elderly. Thus, if someone has a need for assistance in ADL, it is assumed that they will also have a need for assistance in IADL.

While we adjusted for many potential confounders, cognitive function was not assessed in the present study and therefore could not be controlled for. Although cognitive impairment may be a confounder for the association between low vision and IADL restrictions, such an association has been reported in previous study, even after adjusting for cognitive impairment (Sloan et al. 2005).

Visual acuity is only one of many relevant factors in the evaluation of visual function. However, it remains the visual parameter that is most easily and therefore most widely assessed and was precisely measured by ophthalmologists in the present study. Although ROC curve and threshold seeking were univariate analyses, they could be considered as acceptable, as multivariate adjustment did not significantly change the association between visual acuity and IADL (Table 3).

Conclusion

In this study, objectively measured visual impairments were frequent and strongly associated with activity limitations. Assessment of thresholds of visual acuity, associated with IADL limitations, provides information that could form the basis of decisions regarding early clinical interventions, before the beginning of the subjects' decline. Our study tends to demonstrate that beyond a threshold of 20/40 or 20/50, maintaining autonomy is difficult and potential interventions should not be delayed including refractive correction and treatment for major eye diseases. With an ageing population feeding the growing burden of disability in developed countries, ophthalmic surveillance, specifically focused on the elderly, is becoming crucial.

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Conflict of Interest

There is no conflict of interest.

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