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Visual Consequences of Refractive Errors in the General Population

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Objective: To study the frequency and causes of visual impairment in relation to refractive error.

Design: Population-based cohort study.

Participants: A total of 6597 participants from Rotterdam Study I (baseline and 4 follow-up examinations) and 2579 participants from Rotterdam Study II (baseline and 2 follow-up examinations), all 55 years or older, were included.

Methods: Participants underwent an extensive ophthalmic examination, including best-corrected visual acuity and objective refraction, fundus photography, visual field perimetry, and optical coherence tomography imaging of macula and optic disc. We calculated cumulative risks and odds ratios of visual impairment for various refractive error categories and determined causes by using all screening information as well as medical records.

Main Outcome Measures: Unilateral and bilateral low vision (World Health Organization [WHO] criteria, VA <0.3 and VA ≥ 0.05; United States (US) criteria, VA <0.5 and VA ≥ 0.1) and blindness (WHO criteria, VA <0.05; US criteria, VA<0.1).

Results: Cumulative risks of visual impairment ranged from virtually 0 in all refractive error categories at 55 years of age to 9.5% (standard error, 0.01) for emmetropia and 15.3% (standard error, 0.06) for high hyperopia to 33.7% (standard error, 0.08) for high myopia at 85 years of age. The major causes of visual impairment in highly hyperopic persons were age-related macular degeneration (AMD), cataract, and combined causes (each 25%); in highly myopic persons, the major cause was myopic macular degeneration (38.9%). The major causes of visual impairment for the other refractive error categories were AMD and cataract. Compared with those with emmetropia, those with high myopia had a significantly increased lifetime risk of visual impairment; those with -6 diopters (D) or less and -10 D or more had an odds ratio (OR) risk of 3.4 (95% confidence interval [CI], 1.4–8.2) of visual impairment; those with less than -10 D had an OR of 22.0 (95% CI, 9.2–52.6).

Conclusions: Of all refractive errors, high myopia has the most severe visual consequences. Irreversible macular pathologic features are the most common cause of visual impairment in this group. *Ophthalmology 2015;122:101-109 © 2015 by the American Academy of Ophthalmology.*

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Refractive errors—both myopia and hyperopia—are very common human eye disorders and are leading causes of visual impairment worldwide.[1–3] Myopia is characterized by an elongation of the eye and is accompanied by structural changes of the retina and choroid.[4] These changes can lead to potentially blinding complications such as myopic macular degeneration, open-angle glaucoma, and retinal detachment.[5,6] Although all myopic eyes are at risk for complications,[4,7,8] highly myopic eyes, that is, of -6 diopters (D) or more, are particularly at risk of functional blindness developing at a relatively young age. Hyperopia (farsightedness), by contrast, is a condition in which the eye is shortened. For this refractive error category, the risks of visual impairment are less well studied, but it is known that persons with hyperopia have a higher risk of amblyopia, strabismus, and closed-angle glaucoma.[9] An association with age-related macular degeneration (AMD) also has been described.[10]

Although numerous studies have addressed population frequencies of low vision and blindness, none have focused on visual loss as a function of the full spectrum of refractive errors. In addition, frequency of causes of blindness and low vision specified per refractive error category have not been described until now. Given the current rise in prevalence of this trait,[11–13] this information can be useful for clinicians, patients, and researchers and will increase awareness of the visual consequences of refractive errors. In this study, we investigated the frequency and causes of blindness and low vision stratified for various refractive error categories in 2 independent cohorts of the population-based prospective Rotterdam Study.

Methods

Study Population

The rationale and design of the Rotterdam Study have been described in detail elsewhere.[14] In brief, this prospective, population-based follow-up study focused on chronic ophthalmologic,

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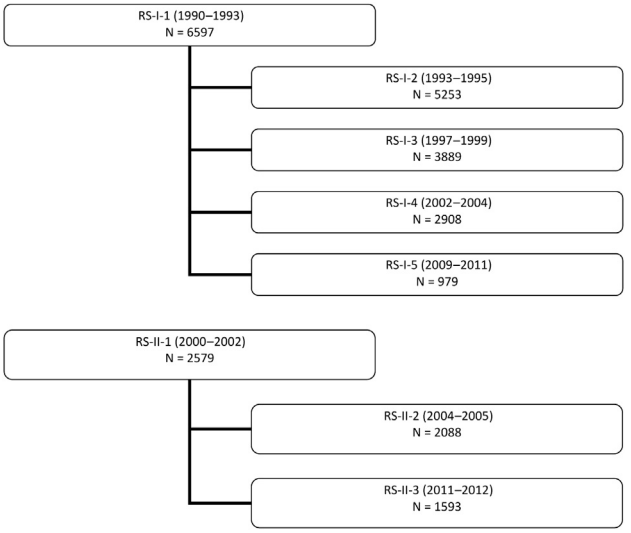

Figure 1. Diagram showing the participation and ophthalmologic measurement from each examination interval of the Rotterdam Study (RS). RS-I-1 = follow-up data for Rotterdam Study I; RS-II-2 = follow-up data for Rotterdam Study II; RS-I-2 = second follow-up measurement of participants of Rotterdam Study I.

Table 2. Characteristics of All Patients with Bilateral Blindness, Low Vision, and Normal Vision at the End Point of the Study (World Health Organization Criteria)

	Bilaterally Blind Subjects (n = 55)	Bilaterally Visually Impaired Subjects (n = 160)	Subjects with Bilateral Visual Acuity ≥0.3 (n = 8961)
Age of onset (yrs)			
Mean ± SD	78.1±11.3	79.7±10.1	NA
Range	55.4–96.3	56.4–106.2	NA
Gender, % men	31.0	53.0	51.0
Spherical equivalent (D)			
Mean ± SD	−0.05±5.78	0.09±4.03	0.75±2.45
Range	−19.13 to 12.25	−15.31 to 8.50	−19.13 to 15.13
High myopia ≤−6 D (%)	9.1	8.1	1.7
Moderate myopia >−6 D and ≤−3 D (%)	5.5	7.5	5.7
Low myopia −3 D and ≤−0.75 D (%)	10.9	10.6	10.4
Emmetropia >−0.75 D and <0.75 D (%)	16.4	19.4	26.0
Low hyperopia ≥0.75 D and <3 D (%)	38.2	38.1	43.6
Moderate hyperopia ≥3 D and <6 D (%)	12.7	13.8	11.4
High hyperopia ≥6 D (%)	7.3	2.5	1.3

D = diopters; NA = not available; SD = standard deviation.

neurologic, cardiovascular, and locomotor diseases in middle-aged and elderly participants living in Ommoord, a city district of Rotterdam, The Netherlands. Baseline data for the ophthalmic part of the study were collected between 1991 and 2002 and follow-up examinations were performed at 2 to 4 years (Fig 1). A total of 99% of study participants were of European descent. For this analysis, we included 9176 participants from 2 independent cohorts of the Rotterdam Study. The first is Rotterdam Study I: 6597 participants 55 years of age and older. Baseline examinations took place between 1990 and 1993, and 4 follow-up examinations were performed in from 1993 through 1995, from 1997 through 1999,

Table 1. Characteristics of the Study Population

	Rotterdam Study I	Rotterdam Study II	Total
No. at baseline	6597	2579	9176
Follow-up time, mean ± SD (yrs)	9.8±6.0	8.9±2.9	9.6±6.1
Baseline age, mean ± SD (yrs)	69.0±9.0	64.1±7.4	67.6±8.8
Gender, % men	41.0	45.0	42.0
Visual acuity at last measurement (WHO criteria), %			
Bilaterally visually impaired subjects	2.2	0.5	1.7
Bilaterally blind subjects	0.8	0.1	0.6
Unilaterally visually impaired subjects	6.1	3.8	5.5
Unilaterally blind subjects	3.4	2.1	3.0
Visual acuity at last measurement (United States criteria), %			
Bilaterally visually impaired subjects	6.6	1.8	5.2
Bilaterally blind subjects	1.1	0.1	0.8
Unilaterally visually impaired subjects	12.5	4.8	10.3
Unilaterally blind subjects	3.4	2.2	3.1
Refractive error			
Spherical equivalent, mean ± SD (D)	0.84±2.54	0.47±2.49	0.74±2.53
High myopia ≤−6 D, %	1.8	1.8	1.8
Medium myopia >−6 D and ≤−3 D, %	5.2	7.3	5.8
Low myopia −3 D and ≤−0.75 D, %	9.5	12.8	10.4
Emmetropia >−0.75 D and <0.75 D, %	25.4	26.9	25.8
Low hyperopia ≥0.75 D and <3 D, %	44.4	41.1	43.4
Medium hyperopia ≥3 D and <6 D, %	12.3	9.2	11.4
High hyperopia ≥6 D, %	1.5	1.0	1.3

D = diopters; SD = standard deviation; WHO = World Health Organization.