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CLINICAL STUDY

Capturing myopia and hypermetropia 'phenotypes' without formal refraction

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Abstract

Purpose **Understanding genetic and environmental factors that together contribute to the development of myopia is an international research priority. We have investigated the feasibility and accuracy of identifying and classifying refractive error, without formal refraction, as a means of easily identifying affected individuals in a large-scale, non-ophthalmological, and population-based survey.**

Methods **At age 44/45 years, members of the 1958 British birth cohort underwent a biomedical, community survey. Refractive error (autorefraction) was measured and categorised by spherical equivalent (SE) measurement; myopia (SE of −1.00 or more extreme), hypermetropia (+1.00 or more extreme), or emmetropia (−0.99 to +0.99). Lenses of prescribed distance glasses, if worn, were assessed as minifying, magnifying, or making no difference to a standard viewed image and cohort members reported on 'short' or 'long' sightedness.**

Results **A total of 2499 cohort members, randomly selected, had formal refraction (autorefraction) and 917 (36.7%) of these individuals had their prescribed distance glasses examined. Sensitivities for myopia and hypermetropia using examination of glasses were over 80% and positive predictive values were 95 and 65% respectively whereas self-report of 'short-sightedness' or 'long-sightedness' had poor accuracy.**

Conclusion **We suggest examination of prescribed distance glasses can be an effective method of 'screening' for refractive error in the field, especially where prevalence is high.**

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Introduction

Myopia is an increasingly important global public health problem with a threefold increase in prevalence in children under 12 years in some countries over the past two decades.[1] Understanding the genetic and environmental factors that together contribute to the development of refractive error (RE) is an international research priority,[2] which parallels the need for genetic epidemiology and investigation of genetic and environmental interactions in other chronic disorders. As very large numbers of affected individuals are needed for such research, there has recently been an expansion of investment in large-scale population-based surveys and cohort studies,[3] which are often conducted in community settings. However, these surveys cannot comprehensively capture all detailed 'phenotypes' at the outset, even when examinations are conducted in dedicated assessment facilities, without high costs, which are often prohibitive. Assessment of refractive status is time consuming and requires specialised personnel and/or expensive equipment (autorefraction). Thus, ways are needed to identify easily affected individuals in general population surveys without, in the first instance, recourse to specialised assessment so that subsequently they can undergo such assessment and refraction can be measured precisely.

We report the feasibility and accuracy of capturing the refractive error 'phenotype' using examination of prescribed distance glasses by non-specialist observers or by self-report of 'short-' or 'long-sightedness'.

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Methods

The 1958 British birth cohort comprises everyone born in Britain in 1 week in 1958.[4] Members have been followed since birth by clinical examination and/or face to face interview. At 7, 11, 16, 41, and 44 years, data were collected at home by a trained nurse on vision and numerous other biological, social, and lifestyle factors.[4] We took the opportunity presented to us by our programme of work on vision and ophthalmic disorders in the 1958 British birth cohort (whose findings will be reported elsewhere) to undertake the present study. It is based on cohort members who had self-reported on vision status at 41 years and subsequently, as part of the biomedical assessment at 44/45 years, had autorefraction and examination of prescribed distance glasses if worn.

All cohort members were asked at 41 years whether they were 'short-' or 'long-sighted'. Questions were supported by a description (eg Are you long sighted? – this means good distance vision, but generally require glasses for reading). Reported eye problems related to both eyes or the worst eye. Individuals reporting eye conditions other than refractive error ($n=86$) were excluded from the analyses. Two individuals reported previous laser treatment but wore glasses and were classified as myopic so were not excluded.

At 44/45 years, a random sample of 2499/9339 (27%) members of the 1958 British birth cohort had autorefraction, using a Nikon Retinomax 2, under non-cycloplegic conditions. Spherical equivalent values (SE), which summarise in a single measure the degree of refractive error, were calculated using the standard formula of the algebraic sum of the dioptric powers of the sphere and half of the cylinder (sphere + 0.5 cylinder).

Refractive status was categorised into three mutually exclusive categories by spherical equivalent measurement on the more extreme eye (the largest absolute SE difference from zero): myopia, (SE = −1 or more extreme), hypermetropia, (SE + 1 or more extreme), otherwise emmetropia.

Prescribed distance glasses were examined by the nurse observer who reported whether both lenses magnified ('plus' lens power for hypermetropia) or conversely minified ('minus' lens power for myopia), or made no difference to the size of a simple standard high contrast image of a cross when it was viewed through the lenses held at reading distance compared to when it was viewed directly. Those having minifying lenses were defined as myopic and those with maximising lenses as hypermetropic. Those with one lens classified and one uncertain were categorised by the classified lens. Sixteen individuals who had one magnifying and one minifying lens were classed as 'unable to categorise'.

Ethical approval for the biomedical study was obtained from South East MREC (ref: 01/1/44). This study is part of a broader programme of work approved by the Institute of Child Health's Research Ethics Committee.

Statistical methods

Assignment of refractive error (myopia or hypermetropia) by examination of prescribed distance glasses or self-report of being short or long sighted were validated using autorefraction measurement as the 'gold standard'. Spherical equivalent measurements were summarised using median and interquartile range (25, 75%).

Sensitivity (probability of testing positive if refractive error is present) and specificity (probability of testing negative if refractive error is not present) were calculated for myopia and hypermetropia separately in those with conclusive glasses examination. Likelihood ratios (relative risk of testing positive compared to testing negative) and positive predictive value (PPV – probability of having refractive error if individual has a positive test) were used to estimate the usefulness of the tests.

Results

Of 9339 cohort members included in the biomedical survey at 44 years, data were available on 2499 individuals with autorefraction readings, which did not differ significantly by sex and social class from those who did not have autorefraction. The distribution of spherical equivalents was skewed and leptokurtotic as would be predicted for a white middle age population in the UK; 1185 (47.4%) were myopic, 286 (11.4%) hypermetropic, and 1028 (41.1%) emmetropic.

Identification of those with myopia and hypermetropia by examination of distance glasses

Cohort members (1011/2499 (40.5%)) reported having prescribed distance correction; 917 individuals had their glasses examined. Of these, 70/112 who wore contact lenses were without 'spare' distance glasses, and 24 individuals did not have their glasses available for examination. Of the 917 individuals who had their glasses examined 561 (61.2%) had lenses reported as minifying, 206 (22.5%) maximising and the remaining 150 (16.4%) the observer could not categorise (Table 1). The median SE and interquartile range (IqR) in individuals with minifying lenses were −3.125 (−4.75, −1.875) and were +1.75 (+0.375, +3.5) in those with maximising lenses. The sensitivities for myopia and hypermetropia were over 80% with specificities of 90 percent. The PPV for myopia was 95%, the lower PPV for hypermetropia (65%) reflected its lower prevalence. Of 206 individuals with maximising lenses 47 (23%) were emmetropic (Table 2).

The majority of those whose glasses were reported by the nurse to leave the image unchanged ($n=109$), or which were difficult to assess ($n=41$), had mild myopia with median SE of −1.375 (−2, −0.75) and −0.875 (−1.25, −0.25), respectively. Thus there was a 59% probability of myopia in individuals whose glasses were not categorised in either direction. Of those whose glasses were assessed as minifying, 4/561 (0.7%) were in fact hypermetropic and had SE values in the range (+1, +6) and of those whose glasses were assessed as maximising 25/206 (12.1%) were myopic and had SE values in the range (−6.25, −1). So overall, 29/767 (3.8%) of those identified as having specific refractive error were misclassified. There were no differences in assessment by observer; misclassification was randomly distributed among observers.

Identification of refractive error by self-report of short or long sight

Of those in the analysis 2314 (93%) had reported on eye problems at 41 years. Refractive error was self-reported by 373 (16%) of these cohort members, comprising 28% of those with true refractive error as measured by autorefraction. The value of the question to identify those with any refractive error was therefore poor, (sensitivity 20%), although 89% of those without any refractive error were correctly identified (Table 3).

Specifically, 236/2314 (10%) of cohort members reported they were short-sighted and 137 (6%) that they were long sighted (Table 1). The median SE value and IqR were −2 (−3.875, −1) and +0.375 (−0.625, +1) of those reporting being short sighted and long sighted, respectively. 26 (11%) of those who reported being short sighted had SE values in the hypermetropic range, (+1, +4.75), and conversely 21 (15%) of those who reported being long-sighted had SE values in the myopic range, (−5.7, −1). This misclassification indicates some confusion in understanding of these lay terms and/or information received about their functional correlates. Those reporting no eye problems had median SE value −0.875 (−1.625, −0.25).

Thus, the ability of self-report using these lay terms to identify refractive error was poor (sensitivities = 16 and 17% for myopia and hypermetropia, respectively). Although the specificities were 95%, this does not compensate for the low sensitivities, when considering the value of self-report as a 'screening' tool.

Table 1 Categorisation of individuals by examination of distance glasses or self-report of refractive error versus spherical equivalent by autorefraction

	n (%)	*Spherical equivalent (SE) by autorefraction*[a]		
		Myopia ($SE \leqslant -1$)	*Emmetropia ($SE > -1$ to $\leqslant +1$)*	*Hypermetropia ($SE \geqslant +1$)*
Report of examination of distance glasses				
$N=917$		$n=629$	$n=141$	$n=147$
Image minified (myopia)	561 (61.2%)	533	24	4[a]
Image magnified (hypermetropia)	206 (22.5%)	25[a]	47	134
Unable to categorise	150 (16.4%)	71	70	9
Self-report of refractive error				
$N=2314$		$n=1101$	$n=960$	$n=253$
Short sight	236 (10.1%)	179	31	26
Long sight	137 (5.9%)	21	72	44

[a]25 + 4/767 (3.8%) individuals, with conclusive measurements, were misclassified.

Table 2 Assessment of myopia and hypermetropia status, by examination of prescribed distance glasses, at 44/45 years, in the 1958 British birth cohort

	Sensitivity	*Specificity*	*Positive predictive value*	*Negative predictive value*	*Positive likelihood ratio*
Myopia					
Minified image	84.7	88.8	95.0	69.7	7.54
Hypermetropia					
Magnified image	91.2	90.2	65.1	98.1	9.25

Table 3 Assessment of refractive error, myopia and hypermetropia status, by self-report of being short and long sighted, at 44/45 years, in the 1958 British birth cohort

	Sensitivity	*Specificity*	*Positive predictive value*	*Negative predictive value*	*Positive likelihood ratio*
Refractive error					
Short/long sighted	19.9	89.3	72.7	44.2	1.86
Myopia					
Short sighted	16.3	95.3	75.9	55.6	3.50
Hypermetropia					
Long sighted	17.4	95.5	32.1	90.4	3.86

Discussion

Autorefraction,[5,6] reliably identifies refractive error in the community, forming the basis of current studies of myopia.[7–9] However, as well as the costs, time and practical constraints of using autorefractors in the field could be prohibitive in the context of very large non-ophthalmological studies. Thus important opportunities for research on refractive error would be missed. We therefore sought to assess the feasibility of collecting refractive status phenotype data in the field with a minimum of equipment and non-specialist but trained observers as a means of identifying individuals of interest for further study.

Our findings support examination of prescribed distance glasses for their ability to magnify or minify a standard image as an effective method of identifying and dichotomising refractive error, especially where the prevalence is high. Of course, this approach is dependent on affected individuals being diagnosed and having prescribed glasses. Those without glasses despite moderate or severe refractive error would not be identified, but this has been found to be uncommon in adults of this age in industrialised countries where personal, educational, occupational, and social demands for good distance vision are high.[10,11]

A good proportion of individuals with mild refractive error were reliably identified by examination of glasses but for some the nurses could not categorise their glasses. This suggests a difficulty in assessing low power lenses, which could be addressed by use of an image which makes minification easier to detect and additional training for observers. We recognise that others with mild refractive error may go undetected – for instance those who either fail to recognise it or elect not to seek treatment because of the visual need, for example, non-drivers. However, early onset myopia, the form that is increasing in many countries, would be likely to be identified as it is more likely to be moderate or severe by adulthood.[12] It may be possible that by combining questions on visual function (with best optical correction if worn), with those on current optical correction, undiagnosed refractive errors may be detected. However, the benefit of identifying the relatively few with undiagnosed refractive error would need to be balanced against the resource used in questioning all participants in a study.

Identification of refractive error by means of self-report of short or long sight as an eye problem (even when questions were supported with explanatory notes on likely functional correlates), was found to be ineffective. This approach requires respondents to perceive they have a vision problem and to understand the terms, and that those with eye problems not related to refraction report these correctly. In our study, 75% of those with refractive error did not report it as a problem and some with extreme SE values reported their refractive error incorrectly, indicating confusion in understanding these lay terms. We suggest that more common use of the medical terms, myopia, and hypermetropia (for short-sightedness and long-sightedness, respectively) in the context of vision testing and health education, could lead to less confusion and improve the usefulness of self-reporting in the future, but currently use of this approach is unlikely to yield useful data.

There are increasing opportunities to exploit large data sets and DNA collections based on population surveys, like UK Biobank,[3] for the study of environmental and genetic associations with disease. However, it is not feasible at the outset of such ventures to identify phenotypes for all conditions of interest in detail. It is necessary to have a mechanism for easily identifying individuals of interest for subsequent selection and detailed assessment of phenotype. We have demonstrated the possibility of reliably identifying those with mild, moderate, or severe refractive error by examination of prescribed distance glasses. This identifies opportunities, which might not otherwise be considered for research on refractive error in the context of large-scale studies of health and disease.

Thus, we suggest this approach may be applicable in ongoing and planned studies where opportunity for formal ophthalmic assessment as a primary procedure does not exist but study of refractive error is of interest and therefore identifying a sampling framework is essential.

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