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A Prospective Study of Spherical Refractive Error and Ocular Components Among Northern Irish Schoolchildren (The NICER Study)

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PURPOSE. To explore 3-year change in spherical refractive error and ocular components among white Northern Irish schoolchildren.

METHODS. Baseline data were collected among 6- to 7-year-old and 12- to 13-year-old children. Three years after baseline, follow-up data were collected. Cycloplegic refractive error and ocular components measurements (axial length [AL], anterior chamber depth [ACD], corneal radius of curvature [CRC]) were determined using binocular open-field autorefraction and ocular biometry. Change in spherical equivalent refractive error (SER) and ocular components were calculated.

RESULTS. A statistically significantly greater change in SER was found between 6 to 7 years and 9 to 10 years (younger cohort) compared to between 12 to 13 years and 15 to 16 years (older cohort) (−0.38 diopter [D] and −0.13 D, respectively) ($P < 0.001$). A statistically significantly greater change in AL was found among the younger compared to the older cohort (0.48 mm and 0.14 mm, respectively) ($P < 0.001$). Change in ACD was minimal across both groups (0.12 mm younger and 0.05 mm older cohort) as were changes in CRC. Change in SER was associated with change in AL in both age groups (both $P < 0.01$).

CONCLUSIONS. There is a greater change in both spherical refractive error and axial length in younger children when compared with teenagers. Although increase in axial length drives refractive change during childhood and teenage years, lens compensation continues to occur in an attempt to maintain emmetropia. White children living in Northern Europe demonstrate dramatically less change in spherical refractive error over a fixed period of time than their East Asian counterparts. In contrast, they appear to exhibit more rapid myopic progression than UK children studied in the mid-20th century.

Keywords: refractive error, myopia, hyperopia, ocular components, prospective study

Cross-sectional report among school-aged children provides some understanding of how the profile of refractive error changes with age and how changes in ocular biometric measurements contribute to this.[1] Prospective studies are more useful as they offer insight into individual progressive characteristics of refractive error and ocular components. A considerable amount of knowledge regarding what happens to refractive error and ocular biometry measurements during childhood has been derived from control groups within intervention studies[2]; however, these studies are specific to myopia progression[3-6] and provide no insight into the prospective characteristics of other refractive error conditions during the school years. Production of robust report on refractive error should be supported by standard consistent study protocols in order to compare between studies. However, these have yet to be established within current cross-sectional and prospective refractive error work where studies use a variety of refractive error definitions,[7,8] non-population-based samples,[9-11] and noncycloplegic[12,13] or possibly inadequate cycloplegic[13,14] regimens for refractive measurement. Protocol standardization has been implemented by the Refractive Error Study in Children (RESC), which collected cross-sectional data at eight sites worldwide[15] but to

date have reported prospectively from only one site in the Shunyi district of China.[8] Various methods for analyses of change in refractive error and ocular components measurements have been reported, including use of mean change in spherical equivalent refractive error (SER),[8,11] mean change in SER with respect to refractive error status,[10,16] and SER and ocular components growth curves.[2,17] Although these studies provide valuable information, the use of different methods of analyses limits between study comparisons.[2] No current, robust, UK-based prospective refractive error and ocular components data exist.

Using robust protocols and presenting change as proposed by the RESC, this prospective study of Northern Irish schoolchildren describes 3-year change in refractive error and ocular components measurements.

METHODS

The Northern Ireland Childhood Errors of Refraction (NICER) Study commenced in 2006. Its primary aim was to investigate the prevalence of childhood myopia. Study methods have been described previously.[18] Briefly, two groups of children were selected as the target population (6–7-year-olds and 12–13-year-

olds) using stratified random cluster sampling to obtain a representative sample from urban/rural and deprived/non-deprived areas.

The study was approved by the University of Ulster's Research Ethics committee and adhered to the tenets of the Declaration of Helsinki. Written consent was obtained from parents or guardians. Data collection included cycloplegic autorefraction (1% cyclopentolate hydrochloride; binocular open-field autorefractor [model SRW-5000; Shin-Nippon, Tokyo, Japan]). No less than five readings were recorded from which the representative value, as determined by the instrument, was used for further analysis. At least three axial length measurements, five anterior chamber depth measurements, and three corneal curvature measurements were recorded by ocular biometry (Zeiss IOLMaster; Carl Zeiss Meditec Inc., Jena, Germany). Lens powers were computed according to Bennett and Rabbetts's method.[19]

Within Phase 1 of the NICER Study, data were collected from 399 6- to 7-year-olds and 669 12- to 13-year-olds. Subsequently, Phase 2 of the NICER Study aimed to collect follow-up data on the same participants. Follow-up of the same participants in Phase 2 occurred 36 months ± 3 months from baseline (Phase 1) when the children were aged 9 to 10 years and 15 to 16 years.

Identical protocols were followed in Phase 1 and 2 with respect to consent, measurement of cycloplegic refractive error, axial length, corneal curvature, and anterior chamber depth.

Definitions

Phase 1 measurements are referred to as baseline. The representative value from the autorefractor was used to calculate SER (sphere + cylinder/2). Baseline SER was defined using the right eye using a system similar to that used by the RESC and the Sydney Myopia Study (SMS).[20,21] A participant was defined as a myope at baseline if SER was −0.50 diopter (D) or less; an emmetrope at baseline if SER was greater than −0.50 D and less than +0.50 D; a mild hyperope at baseline if SER +0.50 D or more and less than +2.00 D; and a moderate hyperope at baseline if SER was +2.00 D or more.

Three-year change in right eye (RE) SER and RE ocular components measurements was defined as: Measurement at Phase 2 − Measurement at baseline.

Statistical Analysis

Statistical analysis was performed using intercooled Stata 10.1 software (StataCorp LP, College Station, TX). Differences between participants and nonparticipants at Phase 2 were investigated with chi-squared tests with respect to age group, sex, spectacle wear at Phase 1, economic deprivation,[18] urban/rural classification,[18] parental myopic status,[18] and grammar school attendance (older cohort only) (Northern Ireland's postprimary school system is composed of grammar and nongrammar schools; entrance to grammar schools is determined by high academic achievement in an assessment prior to progressing to postprimary education at 11–12 years of age). Differences between participants and nonparticipants with respect to SER at Phase 1 were investigated using the Kruskal-Wallis test. Descriptive statistics were calculated for follow-up intervals and t-tests were used for between age cohort comparisons. Overall distributions of change in refractive error and ocular components were assessed for skew and kurtosis and as these tests revealed nonnormal distribution for change in all measured parameters within both age groups, nonparametric analysis was carried out where possible. Associations between change in SER and various continuous variables were assessed using Pearson correlation and partial correlation coefficient from linear regression with adjustment for clustering, age (within age cohorts), time interval, and sex. Associations between change in a continuous variable and refractive error groups were investigated using the Kruskal-Wallis test followed by Wilcoxon rank-sum tests to identify which pairs of refractive error groups showed a Bonferroni-corrected statistically significant difference in the median change in the variable. Apart from between age cohort comparisons, all analyses were performed separately for the two age cohorts.

RESULTS

Participants

All schools within the NICER Study Phase 1 participated in Phase 2. A small number of individuals ($n = 41$ 9–10-year-olds and $n = 33$ 15–16-year-olds) were noncontactable. From Phase 1, overall participation in Phase 2 was 69% (Fig. 1). Similar to the Northern Irish population, 98.5% of the participants at Phase 2 were white; hence, data are reported from white participants only (295 9–10-year-olds [47.5% male], 429 15–16-year-olds [45.4% male]).

The mean ages of the younger and older cohorts at Phase 2 were 10.07 (SD ±0.42) and 16.04 (SD ±0.33) years, respectively. In both cohorts, females were more likely than males to participate (both $P < 0.05$). There was no statistically significant difference between participants and nonparticipants at Phase 2 with respect to all other investigated factors (all $P > 0.09$).
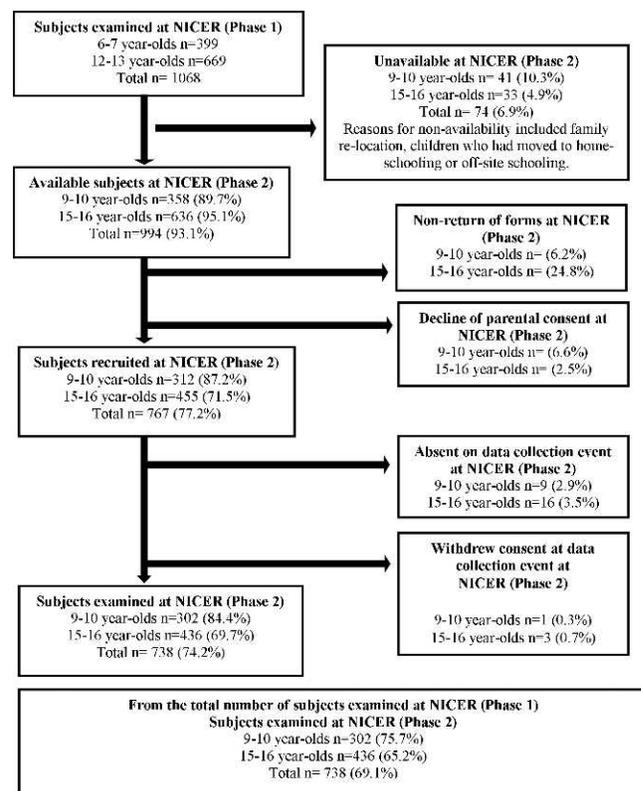

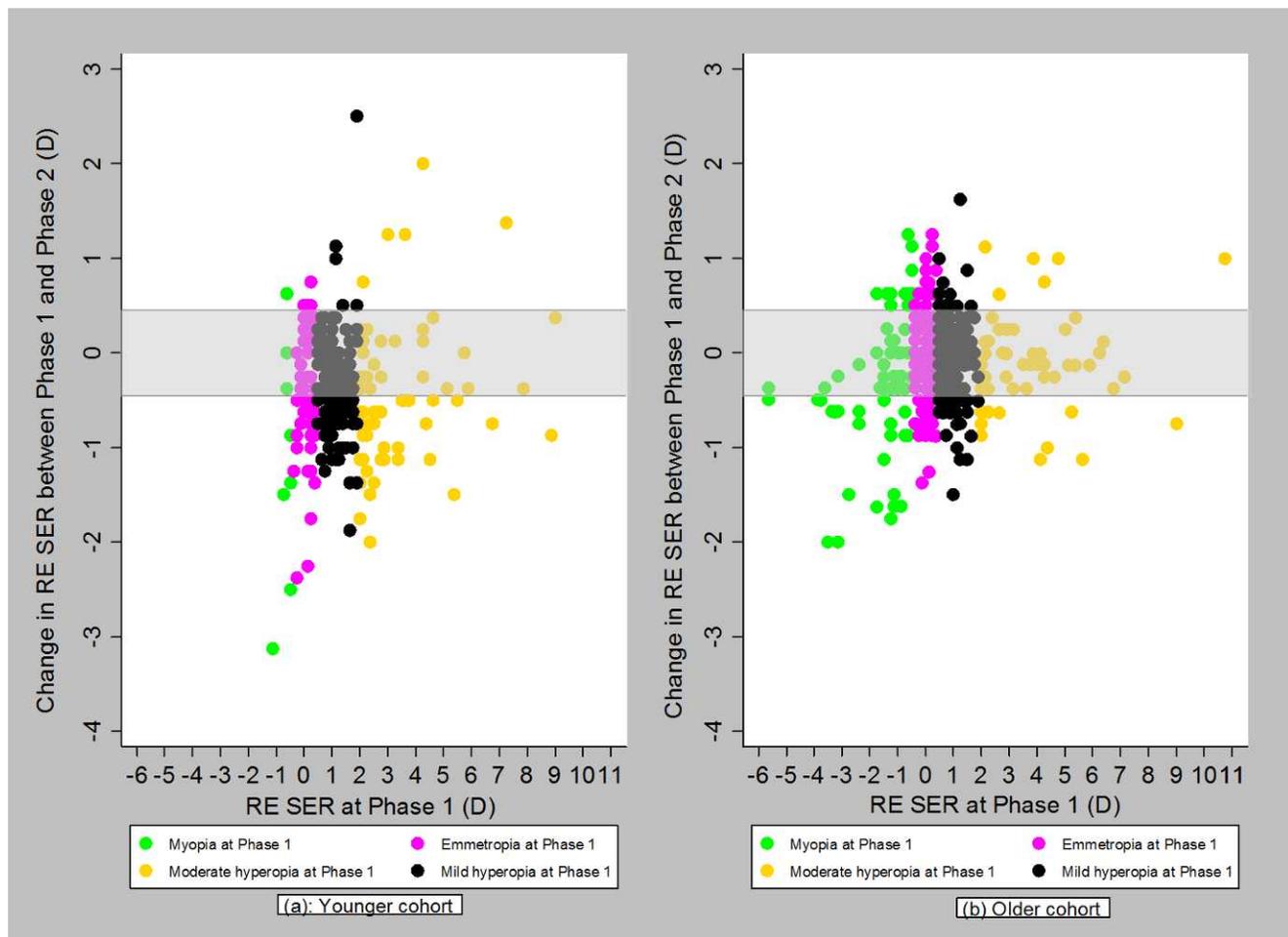FIGURE 1. Flowchart of the study population for the NICER Study (Phase 2).

FIGURE 2. Scatter graph of change in RE SER between baseline and Phase 2 and RE SER at baseline: (**a**) younger cohort; (**b**) older cohort. The *shaded gray area* represents the 95% limits of agreement of the Shin-Nippon autorefractor for interexaminer repeatability of SER measurement.[22]

Follow-up Interval

The younger cohort had a statistically significantly greater mean follow-up interval compared with the older cohort (36.04 months [SD 1.03] and 35.24 months [SD 1.07], respectively, *t*-test, $P < 0.001$).

Change in SER

Within both cohorts there was a statistically significant difference in the SER between Phase 1 and Phase 2 (both $P < 0.001$). The median change in SER between Phase 1 and 2 was statistically significantly greater among the younger compared with the older cohorts (−0.38 D [interquartile range −0.75 D to 0 D] and −0.13 D [interquartile range −0.38 D to +0.25 D], respectively) ($P < 0.001$). There was no statistically significant sex difference in the magnitude of change in SER between either cohort (both $P > 0.48$).

Change in SER With Respect to SER at Baseline

Change in SER with respect to SER at baseline among the younger and older cohorts is shown in Figures 2a and 2b, respectively. Adjusted linear regression analysis showed no statistical association between change in SER between baseline and Phase 2 and baseline SER for both the younger and older cohorts ($P = 0.23$ and $P = 0.10$, respectively).

Change in SER With Respect to Baseline Refractive Error Classification

Among the younger cohort, no association was found between change in SER and refractive error classification at baseline ($P = 0.06$) (Table 1).

However, among the older cohort, a statistically significantly greater change in SER was found between those who were myopic at baseline and those who were emmetropic and mildly hyperopic at baseline (both $P < 0.01$) (Table 1).

Change in Ocular Components Measurements

There was a statistically significant difference in axial length (AL) between baseline and Phase 2 between both cohorts (both $P < 0.001$) with the younger cohort showing the greatest median change in AL ($P < 0.001$) (Table 2). Median change in anterior chamber depth (ACD) between baseline and Phase 2 was statistically significant among both cohorts (both $P < 0.001$) with a greater change found among the younger compared to the older cohort ($P < 0.001$) (Table 2). Within the study period, a statistically significant change in lens power was found among both cohorts (both $P < 0.001$) with greater change evidenced among the younger compared to the older cohort ($P < 0.001$) (Table 2). Among both cohorts there was a statistically significant (both $P < 0.001$) but clinically

TABLE 1. Change in SER Between Baseline (Phase 1) and Phase 2 According to Refractive Status at Baseline (Younger and Older Cohorts)

	Myopia at Phase 1	Emmetropia at Phase 1	Mild Hyperopia at Phase 1	Moderate Hyperopia at Phase 1
Younger cohort				
Median change in SER, D	−1.13 ($n = 8$)	−0.25 ($n = 53$)	−0.38 ($n = 170$)	−0.50 ($n = 64$)
Mean change in SER, D (95% CI)	−1.14 (−3.13-0.63)	−0.35 (−1.75-0.50)	−0.34 (−1.13-0.38)	−0.44 (−1.50-1.25)
Older cohort				
Median change in SER, D	−0.37 ($n = 64$)	0 ($n = 114$)	−0.01 ($n = 196$)	−0.13 ($n = 55$)
Mean change in SER, D (95% CI)	−0.33 (−1.63-0.63)	0.01 (−0.88-0.87)	−0.07 (−0.63-0.50)	−0.10 (−1.01-1)

CI, confidence interval.

insignificant change in corneal radius of curvature (CRC) between baseline and Phase 2 (Table 2).

Change in Ocular Components Measurements and Change in SER

Among both the younger and older cohorts, change in AL was both substantially and statistically significantly negatively correlated with change in SER ($r = 0.51$, $P < 0.001$, and $r = 0.52$, $P < 0.001$, respectively). Likewise, change in lens power was statistically significantly correlated with change in SER among both the younger and older cohorts ($r = 0.54$, $P < 0.001$, and $r = 0.55$, $P < 0.001$). There was no statistically significant correlation between change in ACD, change in CRC, and change in SER.

Linear regression, adjusted for age, sex, and cluster design, showed statistically significant regressions with respect to change in AL and change in SER among both the younger and older cohorts ($R^2 = 0.27$, $P < 0.001$, and $R^2 = 0.27$, $P < 0.01$, respectively).

Associations With Change in AL

Among both the younger and older cohorts, change in AL was statistically significantly negatively correlated with SER at baseline ($r = 0.32$, $P < 0.001$, and $r = 0.23$, $P < 0.001$, respectively) (Figs. 3a, 3b, respectively). Within both cohorts, all between refractive error group comparisons of change in AL were significant (all $P < 0.05$) except between mild hyperopes and moderate hyperopes in the younger cohort and between emmetropes and mild hyperopes and between mild hyperopes and moderate hyperopes in the older cohort (Table 3).

Between baseline and Phase 2, a small number ($n = 18$) of participants from the older cohort showed a decrease in AL (Fig. 3b). Anatomically, these findings are difficult to reconcile; yet, the data are beyond the 95% limits of agreement for repeatability of AL measurements.[22] Consistent with this change in AL, these 18 individuals demonstrated a positive median change in SER (+0.38 D, interquartile range, +0.26 to +0.88 D); however, no correlation was found between change in AL and change in SER among this group of 18 ($P = 0.24$).

Ratio of Change in SER to the Change in AL

Table 4 describes the ratio of change in SER to change in AL between both cohorts.

DISCUSSION

Among the NICER Study participants, greater median change in SER, AL, ACD, and lens power was found between the ages of 6 to 7 years and 9 to 10 years compared with between the ages of 12 to 13 years and 15 to 16 years. Within both cohorts, there was a strong relationship between changes in ocular biometric parameters and changes in SER; however, increase in AL must have been mitigated by lens thinning to achieve the relatively modest decreases measured in SER.

Data that describe change in refractive error and ocular components among white European children are scarce and comparisons with existing data are complicated due primarily to different methods of data presentation. Six-year mean change in SER of −0.54 D among 41 white children with a baseline age of 7 years has been reported by Pointer.[10] With twice the overall follow-up period of the NICER Study and a population sourced from optometric practice, one might expect a greater change in SER within Pointer's study.[10] Other studies have reported change in SER with respect to refractive error classification. For instance, within a study of 1118 Finnish schoolchildren aged 7 to 15 years at baseline, Mäntyjärvi[16] described mean yearly change in noncycloplegic SER of −0.12 D and −0.55 D, respectively, among participants who remained hyperopic ($\geq$+1.00 D) and remained myopic ($\leq$−0.50 D) throughout the study. Mäntyjärvi[16] also described a greater change in SER among younger compared with older children. Perhaps it is more useful to compare the current data with the only other UK study that used repeat cycloplegic measures.[24] Like the NICER Study, Sorsby and Leary[24] described a greater change in refractive error among younger compared with older children in their longitudinal report. However, two main difficulties arise when attempting to make comparisons between Sorsby and Leary's[24] work and the current data. First, Sorsby and Leary[24] categorized participants into two groups, one group that showed an increase in refraction not greater

TABLE 2. Change in Ocular Components Measurements Between Baseline and Phase 2

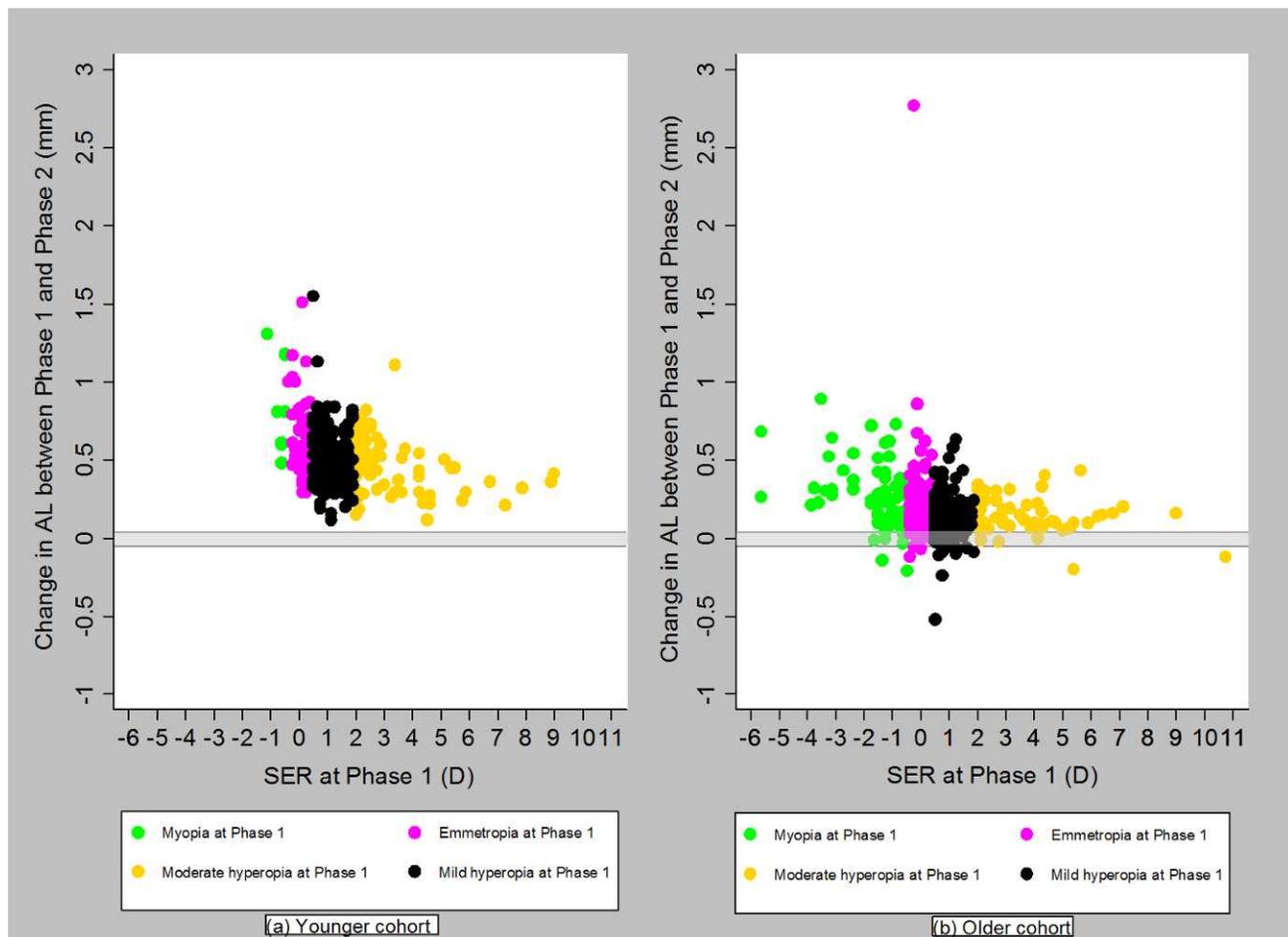|	Younger Cohort	Older Cohort
Median change in AL, mm (IQR)	0.48 (0.40-0.61)	0.14 (0.08-0.24)
Median change in ACD, mm (IQR)	0.12 (0.07-0.17)	0.05 (0.01-0.09)
Median change in CRC, mm (IQR)	0.02 (−0.00-0.04)	0.01 (−0.01 to +0.03)
Median change in lens power, D (IQR)	−1.34 (−1.87 to −0.88)	−0.39 (−0.83 to −0.02)

IQR, interquartile range.

FIGURE 3. Scatter graph of change in RE AL between baseline and Phase 2 and RE SER at baseline: (**a**) younger cohort; (**b**) older cohort. The *shaded gray area* represents the 95% limits of agreement of the Zeiss IOLMaster for interexaminer repeatability of AL measurement.[23]

than 1.31 D and a second group that showed an increase in refraction greater than 1.31 D. Second, Sorsby and Leary's[24] study had variable follow-up periods (mean follow-up period ranged from 5.63 years to 8.33 years). Nevertheless, Sorsby and Leary[24] reported a mean annual rate of change of 0.09 D (±0.07 D) for the group demonstrating less than or equal to 1.31 D of overall change (n = 49) and 0.38 D (±0.14 D) for those demonstrating greater than 1.31 D of overall change (n = 19). When the NICER data are analyzed in a similar way, the mean annual rate of change for participants showing less than or equal to 1.31 D of overall change was 0.10 D (±0.18 D) and 0.02 D (±0.15 D) among the younger (n = 277) and older (n = 419) cohorts, respectively, and the mean annual rate of change for participants showing greater than 1.31 D of overall change was 0.58 D (±0.17 D) and 0.57 D (±0.07 D) among the younger (n = 18) and older (n = 10) cohorts, respectively. So, it appears that contemporary children who are becoming markedly more myopic are doing so more rapidly (approximately 1.5 times) than children growing up in the United Kingdom almost 50 years ago, possibly reflecting significant lifestyle changes that have occurred during this timeframe.

Report of change in refractive error among school-aged East Asian populations is more accessible. The prospective RESC Study based in the Shunyi District in China described a mean 28-month change in SER of −0.42 D (SD 0.68 D) among 4621 East Asian children aged 5 to 13 years at baseline.[8] Surprisingly, this is comparable to the median change found among the younger NICER Study cohort, although presentation of change in SER for the cohort as a whole (as carried out by the RESC) provides no information on change among younger versus older children. Report by Edwards[25] in another East Asian population described mean 5-year change in noncycloplegic SER as −1.62 D among a small group of children (n = 83) aged 7 years at baseline. Notwithstanding the shorter follow-up period, white Northern Irish children show less myopic progression. This is also supported by the more recent report from the Singapore Cohort Study of the Risk Factors of Myopia (SCORM), which described annual mean change in SER of −0.47 D among children aged 7 to 9 years at baseline followed for a 3-year period.[11] Among children of a similar baseline age, Singaporean children are showing more than three times the magnitude of change in SER compared with white Northern Irish children.

Other more recent studies have used complex methods to classify participants with respect to refractive error. Valuable prospective data come from the Orinda Longitudinal Study of Myopia (OLSM), which presents refractive error growth curves among 737 predominantly white (85.0%) children examined on at least three occasions and with a mean baseline age of 8.03 years (calculated by current author).[2] Recent report from the SCORM describes refractive error growth curves using data from at least three visits among 1775 Asian children aged 6 to 10 years at baseline.[17] Both these groups gave consideration to participant's refractive error status at baseline and throughout

TABLE 3. Change in AL Between Baseline and Phase 2 According to Refractive Status at Baseline (Younger and Older Cohorts)

	Myopia at Phase 1	Emmetropia at Phase 1	Mild Hyperopia at Phase 1	Moderate Hyperopia at Phase 1
Younger cohort				
Median change in AL, mm	0.81 ($n = 8$)	0.56 ($n = 53$)	0.46 ($n = 170$)	0.44 ($n = 64$)
Mean change in AL, mm (95% CI)	0.87 (0.48–1.31)	0.62 (0.32–1.12)	0.50 (0.28–0.78)	0.46 (0.21–0.74)
Older cohort				
Median change in AL, mm	0.26 ($n = 64$)	0.17 ($n = 114$)	0.13 ($n = 196$)	0.12 ($n = 55$)
Mean change in AL, mm (95% CI)	0.28 (0.01–0.68)	0.20 (0–0.53)	0.13 (−0.06–0.33)	0.14 (−0.02–0.34)

study. To date, only two data collection points are available for the NICER Study, so we are unable to generate growth curves. As Jones et al.[2] point out, comparison between growth curves and mean change is of limited value. Nevertheless, examination of the SCORM SER growth curves show a greater decrease in SER up to approximately 10 years of age among the cohort as a whole and examination of the OLSM growth curves show a similar picture. These studies support a greater refractive change toward myopia among younger children in line with the current study.

Data describing the relationship between baseline SER and its change during childhood are scarce. Among the younger participants, initial refractive error classification was not a factor in how SER changed within the study period, possibly due to small numbers of baseline myopes within the present cohort. Participants within all baseline refractive error classifications showed change in SER in both a positive and a negative direction. It is a commonly held belief that SER changes in a negative direction during childhood and the current authors are unaware of any previously published data for typically developing children that state otherwise, although such patterns are observed among children with developmental disability.[26] Why some individuals, irrespective of initial refractive status, should become less myopic or more hyperopic is unclear but it should not be assumed that refractive error moves in only one direction during the school years. The limited data that exist on association between baseline refractive error and change in refractive error is contradictory. Edwards[25] reported that schoolchildren with higher levels of myopia at baseline did not show a statistically significantly greater amount of change in SER over a 5-year period. Conversely, the RESC described a more myopic baseline refractive error as a risk factor for myopic progression. Differences in the baseline ages between Edwards[25] and the RESC may contribute to disparities in their reports. Further follow-up of the NICER participants may shed more light on this.

Analogous to the SER changes, change in AL was greater among younger compared with older NICER Study participants. Although this finding was demonstrated by the OLSM for emmetropes, emmetropizing hyperopes, and persistent hyperopes, their AL growth curve for myopes showed little change

in slope between 6 and 15 years of age.[2] Why this should be the case is unclear and does not appear to be due to the combined classification of persistent and incident myopes.[2] Similarities exist between the SCORM data and the NICER Study data with greater rates of change in AL reported among younger compared with older children among all refractive error groups.[17] This is also supported by recent report from 160 young Danish emmetropes, which described comparable median annual change in axial length of 0.23 mm, 0.15 mm, 0.09 mm, and 0.08 mm within the 5.0 to 7.9 years, 8.0 to 10.0 years, 11.0 to 13.9 years, and 14.0 to 15.9 years age groups, respectively.[27] In the OSLM, change in ACD was comparable to that of the NICER Study with continual deepening of the anterior chamber that slowed after 10 to 11 years among all refractive error groups.[2] Interestingly, within the SCORM, an increase in ACD was observed among younger children with a subsequent decrease in depth of the anterior chamber at approximately 10 years of age, resulting in inverted U-shaped growth curves.[17] There appears to be no evidence of this pattern of growth of ACD among NICER Study participants with current data describing increases in ACD up to 15 to 16 years of age.

Growth curves generated by both the OLSM and the SCORM for CRC demonstrate minimal or no change among respective refractive error groupings in agreement with the NICER Study findings.[2,17] These three studies confirm an early report by Fledelius[28] that the cornea plays little role in change in spherical refractive error profile during childhood.

Cross-sectional data from the Sydney Myopia Study (SMS) described high correlation between AL and SER among school-aged children[29]; however, few data exist on the relationship between AL and SER with eye growth. A 2-year longitudinal study among 142 Hong Kong schoolchildren aged 6 to 17 years at baseline described increase in axial length as the main contributor to decrease in SER as mirrored in the current study.[30] The OLSM and the SCORM provide data on lens biometry and show a decrease in lens thickness up to approximately 10 years of age followed by a subsequent increase in lens thickness.[2,17] Within the NICER Study, AL changes are greatest in those with more myopic refractive error at baseline. However, the magnitude of the accompanying myopic shift does not fully correspond to the AL increase,

TABLE 4. Ratio of Change in SER to Change in AL Between Baseline and Phase 2 According to Refractive Status at Baseline (Younger and Older Cohorts)

	Myopia at Phase 1	Emmetropia at Phase 1	Mild Hyperopia at Phase 1	Moderate Hyperopia at Phase 1
Younger cohort				
Ratio change SER/change AL, D/mm	1.22 ($n = 8$)	0.45 ($n = 53$)	0.68 ($n = 170$)	1.07 ($n = 64$)
Older cohort				
Ratio change SER/change AL, D/mm	0.26 ($n = 64$)	0.17 ($n = 114$)	0.13 ($n = 196$)	0.12 ($n = 55$)

suggesting that compensatory lens changes are influential in modifying SER during childhood (including the teenage years) as the eye attempts to maintain emmetropia. This hypothesis is further supported when the NICER data on the ratio of change in SER to change in AL is examined. Among both cohorts and for all refractive error groups, all the ratios are much lower than the well-established relationship that 1-mm change AL equates to 2.5 D of refractive change.[28] This hypothesized lens thickness contribution continues into the second decade of life, beyond the timeframe proposed by the data of Jones et al.[2] and Wong et al.[17] A few NICER Study participants demonstrated a decrease in AL; the reasons for this are not certain, but may be related to change in these particular individuals' crystalline lens index on which the Zeiss IOLMaster measurements are dependant.[31] The possibility of axial length shortening among adult eyes was investigated by Grosvenor[32] within a reanalysis of refractive component data previously published by Sorsby and Leary.[24] However, the cross-sectional nature of the data and the computation methods used to determine axial length make the results inconclusive.[32] More recently, an animal study by Zhu et al.[33] appears to support the concept of eye shrinkage: chicks fitted with positive lenses demonstrated increased choroidal thickness with subsequent decrease in vitreous chamber depth. Within the current study, it is notable that the reduction in AL among these participants tallies with their change in refractive error.

The NICER Study is the first UK-based prospective study to directly measure cycloplegic refractive error and ocular components among schoolchildren within a specified time frame. Identical robust protocols were used at baseline and follow-up. Participation rates at Phase 2 of the NICER Study compare favorably with other studies.[2,7,24] However, the primary aim of the NICER Study (Phase 1) was to investigate the prevalence of myopia among Northern Irish schoolchildren and no consideration was given to future prospective study of changes in refractive error when calculating original sample sizes. Hence, sample sizes may be considered limited when compared with other recently published data.[2,8]

Various demographic factors may be considered to influence whether particular individuals have a change in refractive error resulting in myopia,[8,11–14] and these factors need to be considered within a prospective study that is subject to impact from loss to follow-up. Within the current study, the only factor that showed a statistically significant difference in relation to participation was sex, with females more likely than males to participate at Phase 2.

Collection of data on two occasions allows calculation of median change over a period of time but does not allow generation of growth curves. Phase 3 of the NICER Study has begun and this should facilitate this type of data analysis.

These novel data demonstrate that younger children have greater amounts of change in SRE compared with older children and those children with more myopic SRE at baseline are likely to show the greatest 3-year increase in AL, particularly during preteenage years. Consideration of biometric and refractive data point to continuing lens compensation during both childhood and teenage years. White Northern Irish children show less than a third of the magnitude of annual change in SRE compared with similarly aged Singaporean children. However, myopic progression in the NICER Study appears to be more rapid than that described among children living in the United Kingdom more than 50 years ago, possibly reflecting environmental changes in the intervening years.

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