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Yoga and Kriya for Visual Function and Eye Strain in Children with Low Hyperopia

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ABSTRACT: Low hyperopia adds to the accommodative load of near work, and heavy screen use strains children's eyes, but the effects of yoga-based eye practices are unclear. In this assessor-blinded randomised controlled trial, 60 children aged 11–15 years with low hyperopia (spherical equivalent +0.50 to +1.00 D) in Chennai, India, were allocated to a yoga and kriya programme (n = 30) or their usual routine (n = 30). The 12-week programme, delivered four days a week, combined loosening exercises, suryanamaskar, 30 minutes of candle trataka, pranayama and relaxation. Amplitude of accommodation (AA), unaided distance and near visual acuity (VA, NVA; logMAR), extraocular muscle (EOM) excursion, a study-specific digital eye strain (DES) score and cycloplegic spherical equivalent (SE) were compared by baseline-adjusted analysis of covariance, with Holm correction for the six outcomes. All children completed the study. Compared with controls, the yoga group had higher AA (adjusted difference 1.03 D; 95% CI 0.76 to 1.30), better NVA (−0.058 logMAR; −0.073 to −0.044), greater EOM excursion (0.77 mm; 0.54 to 1.01) and lower DES scores (−4.9 points; −6.5 to −3.3); all $p < 0.001$. Distance VA also differed (−0.036 logMAR; −0.051 to −0.022; $p < 0.001$), but the near and distance acuity differences, about three and two letters, were within usual test–retest variation. Refraction did not change (SE difference −0.002 D; −0.019 to 0.016; $p = 0.86$). In exploratory analyses, physically active children had less eye strain at baseline, and gender, diet, physical activity and media use did not significantly modify the effects, apart from a nominal gender interaction for SE ($p = 0.042$) with no significant change in either gender. A 12-week yoga and kriya programme improved functional measures of accommodation, near acuity and ocular excursion, and symptom scores, in children with low hyperopia, but did not change their refractive error. The changes were statistically robust, but their

clinical importance is uncertain, and they need confirmation in larger, independently conducted trials with validated symptom measures and longer follow-up.

1. INTRODUCTION

Refractive error is the most common cause of reduced vision in children. Hyperopia is common in school-aged children, and its prevalence falls with age as the eye grows (Castagno et al., 2014). Low degrees, such as +0.50 to +1.00 D, are usually left uncorrected because young eyes can compensate by accommodating. However, an uncorrected hyperopic eye must accommodate at every viewing distance, so it carries an extra accommodative load during near work. Moderate uncorrected hyperopia has been linked with poorer early literacy in preschool children (Kulp et al., 2016).

Screen use has added to that near-work load. During online schooling in the COVID-19 pandemic, the daily device use of Indian children roughly doubled, from 1.9 to 3.9 hours, and half of them (50.2%) had digital eye strain (Mohan et al., 2021). Digital eye strain arises partly from stress on accommodation and binocular vision and partly from ocular surface dryness (Sheppard and Wolffsohn, 2018). Accommodative and binocular vision anomalies are also common among school children in Tamil Nadu (Hussaindeen et al., 2017b).

Yoga offers low-cost practices aimed at the eyes. These include eye-movement exercises, palming and the cleansing practices (kriyas), of which trataka, or steady gazing, is the best known. In a randomised trial of 291 adult computer users, 60 days of yoga that included trataka reduced self-rated visual discomfort compared with a wait-list group, although only 117 of the 291 participants were assessed at follow-up (Telles et al., 2006). In a small controlled study of 32 optometry students that did not report random allocation, six weeks of yoga ocular exercises reduced eye fatigue (Gupta and Aparna, 2020). Evidence that eye exercises change refractive error itself is weak: a meta-analysis of Chinese eye exercises found no significant association with myopia after adjustment for confounders (OR 0.87, 95% CI 0.72 to 1.02) (Tang et al., 2023).

To our knowledge, no randomised trial has tested a structured yoga and kriya programme in school children with hyperopia while measuring visual function, refraction and symptoms. This trial asked two questions. First, does a 12-week yoga and kriya programme improve amplitude of accommodation, distance and near visual acuity, extraocular muscle excursion and digital eye strain in children aged 11 to 15 years with low hyperopia, compared with no intervention? Second, does it change their refractive error?

2. MATERIALS AND METHODS

2.1 Study Design and Setting

This was an assessor-blinded, two-arm, parallel-group randomised controlled trial with 1:1 allocation, conducted among school children of classes 6 to 10 in Chennai district, Tamil Nadu, India. The study ran from 15 July to 30 October 2024, and the 12-week intervention was delivered from August to October 2024. The study is reported following the CONSORT 2025 statement (Hopewell et al., 2025).

2.2 Participants

An ophthalmologist screened 400 school children. Children were eligible if they were boys or girls aged 11 to 15 years; had hyperopia, defined as a spherical equivalent (SE) of +0.50 to +1.00 D in at least one eye, measured by the ophthalmologist with retinoscopy after cycloplegic eye drops, without spectacles; and had completed an eye examination by the ophthalmologist. Only children with hyperopia were included; children with myopia were not eligible. Children were excluded if they had any systemic or ocular disorder, were receiving any other treatment, had raised intraocular pressure, or did not provide consent. Seventy children met the eligibility criteria, and the 60 children who gave assent and whose parents gave written informed consent were enrolled. Climate, socio-economic status and daily routine were not controlled.

2.3 Randomisation

The 60 enrolled children were allocated individually in a 1:1 ratio to the yoga and kriya group (n = 30) or the control group (n = 30) using a random number generator that distributed the children equally between the two groups. The first author generated the sequence, enrolled the children and assigned them to groups. No separate person held the sequence, so allocation was not

concealed from the person enrolling the children. The ophthalmologist who assessed the outcomes had no role in generating the sequence, assigning children to groups or delivering the intervention.

2.4 Intervention

The yoga and kriya group practised for 50 minutes a day, 4 days a week, for 12 weeks, from August to October 2024 (Table 1). The main component was trataka, a yogic cleansing practice (kriya) of steady gazing, which took up 30 minutes of every session: participants held a steady fixation on a candle flame, and over the 12 weeks the flame was placed at progressively greater distances. All sessions were conducted in the presence of the first author, a doctoral scholar in yoga science. Adherence was monitored through attendance at the supervised sessions, which averaged 95%, and no child discontinued. Practice outside the supervised sessions was not prescribed or recorded. The control group continued its usual school routine and did not take part in any yoga training. The intervention is described following the TIDieR and CLARIFY checklists (Hoffmann et al., 2014; Moonaz et al., 2021).

Table 1. Yoga and Kriya Module (One Session)

Practice	Type	Dose	Duration (min)
Omkar chanting	Opening	3 to 5 times	1
Sukshma vyayama	Loosening exercises	—	5
Suryanamaskar	Postures	6 rounds	5
Trataka (candle flame)	Kriya (gazing)	Progressive distances	30
Bhastrika	Pranayama	20 counts × 3 sets	1
Kapalabhati	Kriya (breathing)	10 strokes × 3 sets	1
Anuloma viloma (nadi shuddhi)	Pranayama	—	1–2
Shavasana	Relaxation	—	5
Total			**49–50**

2.5 Outcome Measures

All outcomes were measured at baseline and after the programme by the same ophthalmologist, and the readings and eye examinations were done under identical conditions at both visits. The ophthalmologist visited only to take the children's readings, which were all made in his presence, and did not attend the yoga sessions, so he was not aware of the children's group allocation. Because the children knew their allocation, their responses to the DES questionnaire could not be blinded. Values for the right and left eyes were averaged.

Amplitude of accommodation (AA). AA was measured for each eye with the RAF near-point rule using the push-up method. The near point in centimetres was converted to dioptres as AA = 100 / near point (cm). Because AA was measured without spectacles, the measured amplitude of a hyperopic eye includes the accommodation needed to overcome the hyperopia.

Distance visual acuity (VA). Unaided distance VA was recorded on a Snellen chart at 20 feet. It was also scored letter by letter on the logMAR scale, at 0.02 logMAR per letter. Each eye was tested separately, without spectacles, under identical conditions at baseline and after the programme. The logMAR score was analysed, and lower values indicate better acuity. The Snellen line was used to classify change in whole lines.

Near visual acuity (NVA). Unaided NVA was recorded in logMAR and scored letter by letter, at 0.02 logMAR per letter. Lower values indicate better acuity. Each eye was tested separately; the type of near chart and the test distance were not recorded.

Extraocular muscle (EOM) excursion. EOM excursion was measured with a standardised ocular excursion assessment. Children were seated with the head stabilised and followed a fixation stick held 40 cm away, which was moved slowly into the

six cardinal positions of gaze (up-right, right, down-right, down-left, left and up-left). In each direction, excursion was measured in millimetres as the displacement of the corneal limbus from the primary position to the point of maximum gaze, using a translucent millimetre ruler. The values for the six directions were averaged; larger values indicate greater excursion.

Digital eye strain (DES). DES was measured with a structured questionnaire developed for this study and adapted from the visual discomfort questionnaire of Vinkers et al. (2024). It has 15 items, each rated on a 1 to 10 scale; the total score (possible range 15 to 150) was analysed, and higher scores indicate more symptoms. The questionnaire was not validated before use. Its items were adapted from an existing instrument, but its internal consistency, test–retest reliability, responsiveness and minimal important difference have not been established in children, and item-level data were not available to estimate internal consistency in this sample. The score is therefore a study-specific symptom measure rather than a validated measure of digital eye strain. The questionnaire is available from the corresponding author on request.

Refraction. Cycloplegic retinoscopy was repeated after the programme. SE (sphere plus half the cylinder, in D) was analysed; positive values indicate hyperopia.

Lifestyle factors. Age, gender, diet (eye-healthy food or no specific diet), media addiction (low or high) and physical activity (high or low) were recorded at baseline with a custom questionnaire completed by the children and their parents. High media addiction was defined as more than 3 hours of screen time a day; physical activity was classified from the child's reported daily playtime, and diet from the foods the child reported eating. These were study-specific two-level classifications.

Adverse events. Adverse effects such as eye irritation, watering, headache and dizziness were monitored at each session.

2.6 Statistical Analysis

All randomised children completed follow-up and were analysed in their allocated group. Continuous variables are presented as mean ± SD and categorical variables as n (%). Normality was checked with the Shapiro–Wilk test. AA, VA, NVA and DES values were approximately normal at baseline and after the programme (all $p \geq 0.06$), whereas EOM values were not ($p = 0.001$ and 0.003) and post-programme SE was not ($p = 0.014$). The ANCOVA residuals were approximately normal for VA, EOM, DES and SE (all $p > 0.05$) but not for AA ($p = 0.044$) or NVA ($p = 0.022$). Distance and near VA (letter-scored logMAR) and EOM take only a few discrete values, so non-parametric checks were run for every outcome.

For each outcome, the between-group comparison used analysis of covariance (ANCOVA) with the post-intervention value as the dependent variable, group as the factor and the baseline value as the covariate. ANCOVA adjusts for chance baseline imbalance and has more power than comparing change scores (Vickers and Altman, 2001). Results are given as baseline-adjusted mean differences (yoga minus control) with 95% confidence intervals (CI) and partial η^2. The group × baseline interaction was non-significant for all outcomes ($p = 0.21$ to 0.73), supporting homogeneity of regression slopes. No primary outcome was designated in advance. All six outcomes (AA, VA, NVA, EOM, DES and SE) are reported, and their six between-group comparisons were treated as one family of tests. The family-wise error rate was held at 5% with the Holm step-down procedure (Holm, 1979): the six ANCOVA p-values were ranked from smallest to largest, the smallest was compared with 0.05/6, the next with 0.05/5, and so on, and testing stopped at the first comparison that did not reach its threshold. Holm-adjusted p-values are reported alongside the unadjusted values in the Results. The analyses reported here were specified after data collection, and no statistical analysis plan was registered.

The between-group results were checked with (1) a rank-based ANCOVA, (2) the Mann–Whitney U test on change scores, (3) the group × time interaction of a two-way mixed ANOVA, and (4) an ANCOVA additionally adjusted for age and gender. Hedges' g was calculated for the difference in change scores. Within-group change was tested with the paired t-test (AA, DES and SE) or the Wilcoxon signed-rank test (VA, NVA and EOM). Changes in VA were also classified as improved (≥ 1 Snellen line of distance VA), unchanged or worse and compared between groups with Fisher's exact test.

Effect modification and covariates. Two-way ANCOVA models containing group, factor and their interaction, with the baseline value as covariate, tested the main effect of gender, diet, physical activity and media addiction on each outcome and whether each factor modified the yoga effect; the yoga effect was also estimated within each subgroup. A multivariable ANCOVA then entered group, baseline value, age, gender, diet, physical activity and media addiction together. Baseline outcome values were compared between factor levels with independent t-tests.

Correlations. Associations between outcomes were assessed with Spearman's ρ at baseline (pooled sample), between change scores within the yoga group, and as partial correlations between change scores controlling for group.

Clinical significance. To distinguish statistical significance from clinical importance, the between-group differences were compared with external benchmarks: 0.10 logMAR (five letters) for acuity, because changes of this size or smaller cannot be reliably distinguished from no change on ETDRS charts (Rosser et al., 2003); 1.50 D for push-up AA, proposed as the minimum significant change between repeated measurements in young adults (Rosenfield and Cohen, 1996); half the baseline SD (1.9 points) for the DES score (Norman et al., 2003); and 0.25 D, the smallest step used in clinical refraction, for SE. No benchmark was available for EOM excursion, which was recorded in 0.5 mm steps. Relative change was expressed as a percentage of the baseline mean for AA, EOM and DES, and as letters (0.02 logMAR per letter) for VA and NVA. Responder analyses compared the proportion of children with a DES reduction of at least half the baseline standard deviation (≥ 1.9 points), a distribution-based estimate of a minimally important change (Norman et al., 2003); a gain, or loss, of at least one Snellen line of distance VA; an NVA gain of at least 0.10 logMAR; an AA gain of at least 1 D; AA below Hofstetter's age-expected minimum, 15 − 0.25 × age (Hofstetter, 1950), after the programme; and any increase in EOM excursion. Groups were compared by risk difference (Newcombe 95% CI), relative risk (RR) and number needed to treat (NNT), with Fisher's exact test.

The within-group tests and the effect-modification, covariate, correlation and responder analyses were exploratory and were not corrected for multiple testing; their p-values should be read as descriptive. No sample-size calculation was performed before the trial. As a detectable-effect assessment, 30 children per group give 80% power to detect a standardised difference of $d = 0.74$ (two-sided $\alpha = 0.05$). Tests were two-sided with $p < 0.05$ taken as significant. Analyses were performed in Python 3.13.17 with pandas 3.0.5, NumPy 2.5.3, SciPy 1.18.1 and statsmodels 0.15.0, and figures were drawn with Matplotlib 3.11.2.

3. RESULTS AND DISCUSSION

3.1 Participant Flow and Baseline Characteristics

Of 400 children screened, 70 were eligible and 60 were randomised, 30 to each group. Brief redness and watering of the eyes were reported during sessions in the yoga group. All 60 completed the post-intervention assessment and were analysed (**Figure 1**). The groups were similar at baseline in age, gender, diet, media addiction, physical activity and all six outcomes (Table 2).

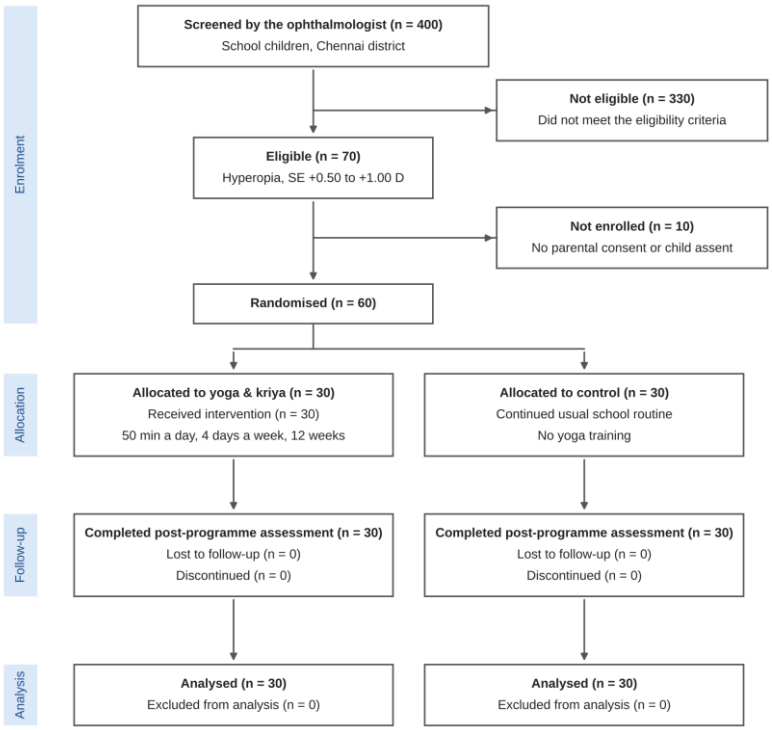


Figure 1. Flow of participants through the trial (CONSORT diagram).

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Table 2. Baseline Characteristics of the Study Groups

Characteristic	Yoga & kriya (n = 30)	Control (n = 30)	p
Age, years, mean ± SD (range)	13.3 ± 1.5 (11–15)	13.1 ± 1.3 (11–15)	0.511[a]
Male, n (%)	16 (53.3)	15 (50.0)	0.796[b]
Eye-healthy diet, n (%)	15 (50.0)	14 (46.7)	0.796[b]
High media addiction (> 3 h screen time/day), n (%)	19 (63.3)	15 (50.0)	0.297[b]
High physical activity, n (%)	20 (66.7)	18 (60.0)	0.592[b]
SE, D	+0.75 ± 0.13	+0.75 ± 0.13	0.936[a]
AA, D	10.60 ± 0.95	10.66 ± 0.84	0.811[a]
VA, logMAR	0.121 ± 0.046	0.117 ± 0.043	0.728[a]
NVA, logMAR	0.195 ± 0.054	0.203 ± 0.054	0.570[a]
EOM excursion, mm	7.15 ± 0.62	7.10 ± 0.56	0.744[a]
DES score	46.0 ± 3.7	46.6 ± 3.9	0.565[a]

Values are mean ± SD unless stated. [a]Independent t-test. [b]Chi-square test. SE, cycloplegic spherical equivalent; AA, amplitude of accommodation; VA, distance visual acuity; NVA, near visual acuity; EOM, extraocular muscle; DES, digital eye strain.

At baseline, 29 of 30 children in each group had AA below the minimum expected for age by Hofstetter's formula, 15 − 0.25 × age (Hofstetter, 1950), but few were more than 2 D below it: 3 in the yoga group and 2 controls. The mean shortfall from the age-expected minimum was −1.07 D in the yoga group and −1.08 D in controls.

In baseline comparisons of the pooled sample, boys and girls had similar AA (10.66 ± 0.76 vs 10.60 ± 1.02 D; p = 0.808). Children with high media addiction had slightly lower AA than those with low media addiction, although the difference was not significant (10.47 ± 0.95 vs 10.84 ± 0.78 D; p = 0.110), and tended to have smaller EOM excursion (7.00 ± 0.54 vs 7.29 ± 0.62 mm; p = 0.058). Children with high physical activity had lower DES scores than those with low activity (45.4 ± 3.7 vs 47.9 ± 3.4; p = 0.014) and tended to have better NVA (0.189 ± 0.057 vs 0.216 ± 0.045 logMAR; p = 0.062). Children eating eye-healthy food tended to have lower DES scores (45.4 ± 4.0 vs 47.2 ± 3.4; p = 0.062) and had better VA (0.108 ± 0.048 vs 0.130 ± 0.037 logMAR; p = 0.045) and NVA (0.183 ± 0.056 vs 0.214 ± 0.048 logMAR; p = 0.026), with slightly less hyperopia (SE +0.72 ± 0.13 vs +0.78 ± 0.12 D; p = 0.074).

3.2 Effect of the Yoga and Kriya Programme

After the programme, the yoga and kriya group scored better than the control group on AA, VA, NVA, EOM and DES after adjustment for baseline (all p < 0.001 after Holm correction), whereas SE did not differ (p = 0.858; Tables 3 and 4; **Figures 2 and 3**).

Table 3. Outcomes at Baseline and after the Programme, with Within-Group Change

Outcome	Group	Baseline	Post	Change (95% CI)	% change	p
AA, D	Yoga	10.60 ± 0.95	11.74 ± 0.89	1.14 (0.88 to 1.40)	+10.7	< 0.001
	Control	10.66 ± 0.84	10.75 ± 0.77	0.09 (−0.06 to 0.25)	+0.9	0.236
VA, logMAR	Yoga	0.121 ± 0.046	0.083 ± 0.044	−0.038 (−0.047 to −0.029)	+1.9[a]	< 0.001
	Control	0.117 ± 0.043	0.117 ± 0.042	−0.001 (−0.014 to 0.013)	0.0[a]	0.895
NVA, logMAR	Yoga	0.195 ± 0.054	0.133 ± 0.061	−0.062 (−0.073 to −0.051)	+3.1[a]	< 0.001
	Control	0.203 ± 0.054	0.199 ± 0.057	−0.004 (−0.013 to 0.005)	+0.2[a]	0.407

Outcome	Group	Baseline	Post	Change (95% CI)	% change	p
EOM, mm	Yoga	7.15 ± 0.62	8.10 ± 0.58	0.95 (0.71 to 1.19)	+13.3	< 0.001
	Control	7.10 ± 0.56	7.30 ± 0.52	0.20 (0.05 to 0.35)	+2.8	0.014
DES score	Yoga	46.0 ± 3.7	40.2 ± 4.3	−5.8 (−7.4 to −4.3)	−12.7	< 0.001
	Control	46.6 ± 3.9	45.5 ± 3.5	−1.1 (−2.1 to −0.2)	−2.4	0.019
SE, D	Yoga	+0.75 ± 0.13	+0.75 ± 0.12	−0.003 (−0.016 to 0.011)	—	0.689
	Control	+0.75 ± 0.13	+0.75 ± 0.12	−0.001 (−0.014 to 0.011)	—	0.832

Values are mean ± SD. % change is relative to the baseline mean; [a]for VA and NVA, letters gained (0.02 logMAR per letter); —, not applicable. p from the paired t-test (AA, DES, SE) or Wilcoxon signed-rank test (VA, NVA, EOM).

Table 4. Between-Group Comparison after Adjustment for Baseline (ANCOVA)

Outcome	Adjusted difference (95% CI)	F(1, 57)	p	Holm p	Partial η^2	Hedges' g
AA, D	1.03 (0.76 to 1.30)	57.4	< 0.001	< 0.001	0.50	1.79
VA, logMAR	−0.036 (−0.051 to −0.022)	24.8	< 0.001	< 0.001	0.30	−1.21
NVA, logMAR	−0.058 (−0.073 to −0.044)	65.1	< 0.001	< 0.001	0.53	−2.06
EOM, mm	0.77 (0.54 to 1.01)	42.9	< 0.001	< 0.001	0.43	1.39
DES score	−4.9 (−6.5 to −3.3)	36.9	< 0.001	< 0.001	0.39	−1.37
SE, D	−0.002 (−0.019 to 0.016)	0.03	0.858	0.858	< 0.01	−0.04

Adjusted difference = yoga minus control. p, unadjusted; Holm p, adjusted for the six outcomes with the Holm step-down method. All p-values except that for SE remain < 0.001 after Holm correction (SE, Holm-adjusted p = 0.858). For VA, NVA and DES, negative values favour the yoga group; for SE, negative values indicate less hyperopia. Hedges' g is calculated on change scores.

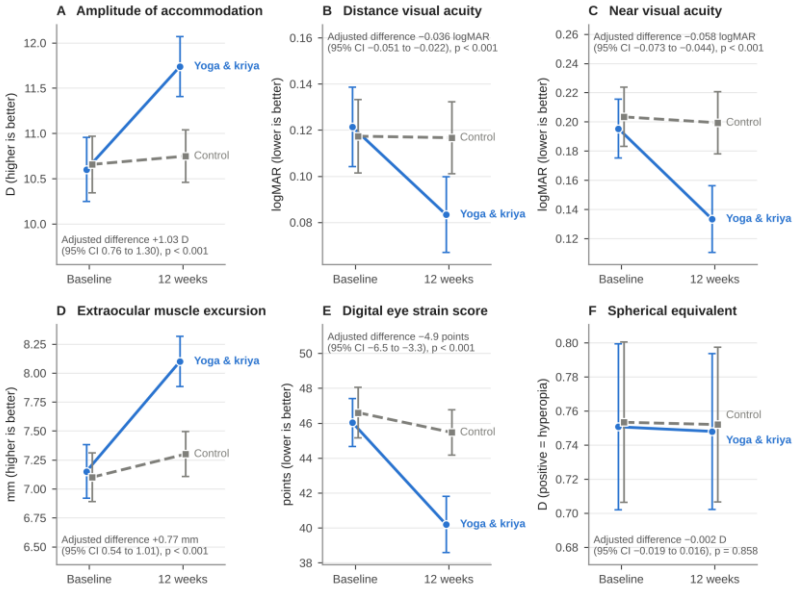


Figure 2. Group means with 95% confidence intervals at baseline and after the programme for (A) amplitude of accommodation, (B) distance visual acuity, (C) near visual acuity, (D) extraocular muscle excursion, (E) digital eye strain score and (F) spherical equivalent. The text in each panel gives the baseline-adjusted difference between groups (yoga minus control) from ANCOVA; this difference is not itself plotted.

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AA rose by 1.14 D in the yoga group, and 29 of 30 children improved, whereas it did not change significantly in controls (+0.09 D; p = 0.236). The adjusted difference was 1.03 D (95% CI 0.76 to 1.30; partial η^2 = 0.50).

NVA improved by 0.062 logMAR (3.1 letters) in the yoga group and by 0.004 logMAR (0.2 letters) in controls (p = 0.407). In the yoga group, 29 of 30 children read more letters, 1 read the same number and none read fewer; in controls, 11 read more, 11 the same and 8 fewer. Eight children in the yoga group (27%) and none of the controls gained a full line (≥ 0.10 logMAR). The adjusted difference was −0.058 logMAR (95% CI −0.073 to −0.044), the largest standardised effect of the six outcomes (partial η^2 = 0.53; Hedges' g = −2.06).

Distance VA improved by 0.038 logMAR (1.9 letters) in the yoga group and did not change in controls (0.0 letters; p = 0.895). In the yoga group, 26 children read more letters, 4 read the same number and none read fewer; in controls, 11 read more, 8 the same and 11 fewer. In whole Snellen lines, 9 children in the yoga group gained a line and none lost one, whereas 3 controls gained a line and 5 lost one (**Figure 4**). The number of children with acuity of 20/25 or better rose from 22 to 28 in the yoga group and fell from 24 to 23 in controls. The adjusted difference was −0.036 logMAR (95% CI −0.051 to −0.022; partial η^2 = 0.30).

EOM excursion increased by 0.95 mm in the yoga group (26 improved, 4 unchanged, none worse) and by 0.20 mm in controls (p = 0.014). The adjusted difference was 0.77 mm (95% CI 0.54 to 1.01). The DES score fell by 5.8 points in the yoga group, with 28 of 30 children scoring lower, and by 1.1 points in controls (p = 0.019). The adjusted difference was −4.9 points (95% CI −6.5 to −3.3).

Cycloplegic SE did not change in either group (yoga −0.003 D, p = 0.689; control −0.001 D, p = 0.832), and in each group about as many children moved towards more hyperopia as towards less (yoga 13 and 14; controls 14 and 14). The adjusted difference was −0.002 D (95% CI −0.019 to 0.016; p = 0.858), so the functional gains were not accompanied by any change in hyperopia.

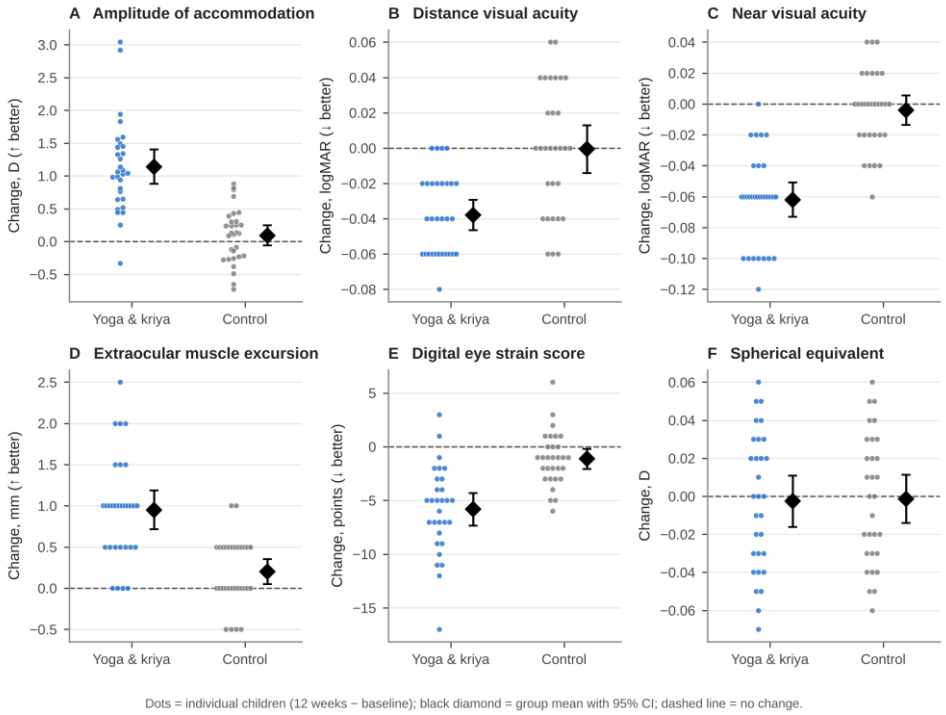


Figure 3. Change from baseline to post-intervention for each child: (A) amplitude of accommodation, (B) distance visual acuity, (C) near visual acuity, (D) extraocular muscle excursion, (E) digital eye strain score and (F) spherical equivalent. Dots are individual children; the black diamond is the group mean with 95% CI; the dashed line marks no change.

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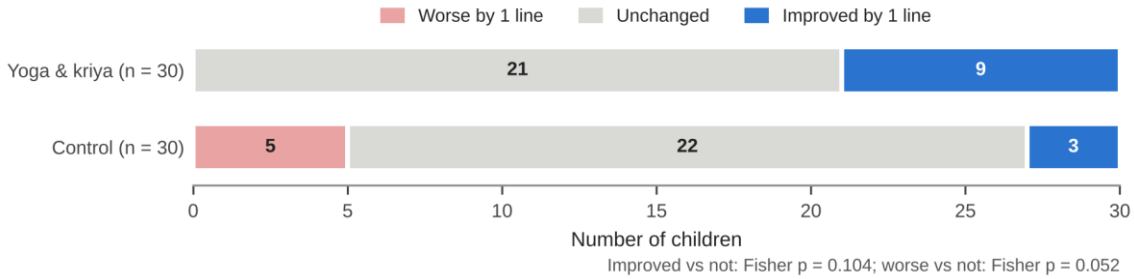


Figure 4. Change in distance visual acuity in Snellen lines by group. Improved vs not: Fisher p = 0.104; worse vs not: Fisher p = 0.052.

3.3 Clinical Significance in Relative Terms (Exploratory)

The analyses in Sections 3.3 to 3.5 are exploratory. In relative terms, AA in the yoga group rose by 10.7% from baseline, compared with 0.9% in controls. Distance VA improved by 1.9 letters vs 0.0 letters and NVA by 3.1 vs 0.2 letters, EOM excursion increased by 13.3% vs 2.8%, and the DES score fell by 12.7% vs 2.4% (Table 3). The mean near point of accommodation, calculated from the mean AA, moved from 9.4 to 8.5 cm in the yoga group and from 9.4 to 9.3 cm in controls. The mean shortfall in AA relative to Hofstetter's minimum changed from −1.07 to +0.06 D in the yoga group, so that the group mean reached the age-expected minimum, and from −1.08 to −0.98 D in controls.

In the responder analysis (Table 5), children in the yoga group were 3.0 times as likely as controls to gain a Snellen line of distance acuity (30% vs 10%), but the difference was not significant (p = 0.104), and none lost a line, against 17% of controls (p = 0.052). Eight children in the yoga group (27%) and no controls gained at least 0.10 logMAR in near acuity (p = 0.005), and 17 (57%) and no controls gained at least 1 D of AA (p < 0.001). Children in the yoga group were 2.1 times as likely to show a fall in DES score of at least half a standard deviation and 1.9 times as likely to show increased EOM excursion. After the programme, the yoga group was less than half as likely as the control group to have AA below the age-expected minimum (43% vs 97%; RR 0.45).

Table 5. Responder Analysis: Proportion of Children Reaching Clinically Relevant Thresholds

Criterion	Yoga, n (%)	Control, n (%)	Risk difference, % (95% CI)	RR (95% CI)	NNT (95% CI)	p
VA improved by ≥ 1 Snellen line	9 (30.0)	3 (10.0)	20.0 (−0.5 to 39.0)	3.00 (0.90 to 10.01)	5.0[a]	0.104
VA worse by ≥ 1 line	0 (0.0)	5 (16.7)	−16.7 (−33.6 to −2.0)	—	6.0 (3.0 to 50.7)[b]	0.052
NVA improved by ≥ 0.10 logMAR	8 (26.7)	0 (0.0)	26.7 (9.8 to 44.4)	—	3.8 (2.2 to 10.2)	0.005
AA gain ≥ 1 D	17 (56.7)	0 (0.0)	56.7 (35.8 to 72.6)	—	1.8 (1.4 to 2.8)	< 0.001
AA below age minimum after programme	13 (43.3)	29 (96.7)	−53.3 (−69.5 to −31.4)	0.45 (0.30 to 0.68)	1.9 (1.4 to 3.2)	< 0.001
DES fall ≥ 0.5 SD (≥ 1.9 points)	27 (90.0)	13 (43.3)	46.7 (23.2 to 63.9)	2.08 (1.36 to 3.18)	2.1 (1.6 to 4.3)	< 0.001
EOM excursion increased	26 (86.7)	14 (46.7)	40.0 (16.3 to 58.3)	1.86 (1.24 to 2.79)	2.5 (1.7 to 6.1)	0.002

RR, relative risk (not estimable when a group had no events); NNT, number of children who need to practise yoga for one additional child to reach the criterion (or to avoid it, for adverse criteria). p from Fisher's exact test. Thresholds were defined after data collection. [a]No NNT interval is given because the 95% CI of the risk difference includes zero, so the interval would

run from benefit through infinity to harm. [b]The Newcombe CI of the risk difference excludes zero but Fisher's exact p is 0.052; the two methods are calculated differently and can disagree when a result is close to the 0.05 threshold.

3.4 Correlations Between Outcomes (Exploratory)

At baseline, distance and near acuity were closely related to the degree of hyperopia (VA–SE $\varrho = 0.87$; NVA–SE $\varrho = 0.82$; both $p < 0.001$) and to each other ($\varrho = 0.73$, $p < 0.001$), and children with more hyperopia had lower measured AA ($\varrho = -0.49$, $p < 0.001$), as expected when AA is measured without correction (Table 6). Children with higher AA had better near acuity ($\varrho = -0.47$, $p < 0.001$), and children with greater EOM excursion had better near acuity ($\varrho = -0.37$, $p = 0.004$). Children with poorer near acuity reported more eye strain ($\varrho = 0.66$, $p < 0.001$), as did those with smaller EOM excursion ($\varrho = -0.50$, $p < 0.001$); eye strain was also weakly related to distance acuity ($\varrho = 0.28$, $p = 0.032$) and SE ($\varrho = 0.35$, $p = 0.007$), but not significantly to AA ($\varrho = -0.19$, $p = 0.145$). Age was strongly related to AA ($\varrho = -0.77$, $p < 0.001$), as expected from the decline of accommodation with age, and weakly to SE ($\varrho = 0.26$, $p = 0.041$), but not to the other outcomes.

Changes in AA and near acuity were closely linked: with group controlled, larger AA gains went with larger NVA improvements (partial $\varrho = -0.83$, $p < 0.001$; within the yoga group $\varrho = -0.88$, $p < 0.001$). Larger AA gains also went with larger falls in DES score (partial $\varrho = -0.29$, $p = 0.027$; within the yoga group $\varrho = -0.37$, $p = 0.044$), and larger NVA improvements went with larger falls in DES score within the yoga group ($\varrho = 0.44$, $p = 0.014$), although the partial correlation for the whole sample was not significant ($\varrho = 0.24$, $p = 0.069$). Changes in distance VA went with changes in SE (partial $\varrho = 0.40$, $p = 0.002$), so children whose refraction became slightly more hyperopic tended to lose letters. Within the yoga group, larger AA gains also went with larger distance VA gains ($\varrho = -0.47$, $p = 0.008$), and larger NVA gains went with larger EOM gains ($\varrho = -0.44$, $p = 0.014$). The other change-score correlations were small and non-significant (partial $|\varrho| \leq 0.23$).

Within the yoga group, children who started with lower AA, poorer distance VA or smaller EOM excursion improved most ($\varrho = -0.51$, -0.39 and -0.55; $p = 0.004$, 0.035 and 0.002), whereas the gain in NVA did not depend on baseline NVA ($\varrho = -0.01$, $p = 0.956$), and baseline DES and SE were not significantly related to their change ($\varrho = -0.27$ and -0.30; $p = 0.152$ and 0.110). Part of this pattern is expected from regression to the mean, because children whose baseline values were poorer partly by chance tend to score closer to the average at follow-up.

Table 6. Spearman Correlations between Outcomes, ϱ (p)

Pair	Baseline, pooled (n = 60)	Change, partial (controlling for group)	Change, yoga group (n = 30)
AA – VA	−0.23 (0.077)	−0.20 (0.127)	−0.47 (0.008)
AA – NVA	−0.47 (< 0.001)	−0.83 (< 0.001)	−0.88 (< 0.001)
AA – EOM	0.12 (0.369)	−0.08 (0.563)	0.30 (0.103)
AA – DES	−0.19 (0.145)	−0.29 (0.027)	−0.37 (0.044)
AA – SE	−0.49 (< 0.001)	0.04 (0.781)	0.12 (0.543)
VA – NVA	0.73 (< 0.001)	0.23 (0.076)	0.24 (0.194)
VA – EOM	−0.24 (0.060)	0.04 (0.790)	−0.28 (0.128)
VA – DES	0.28 (0.032)	0.11 (0.392)	0.13 (0.493)
VA – SE	0.87 (< 0.001)	0.40 (0.002)	0.26 (0.162)
NVA – EOM	−0.37 (0.004)	0.03 (0.847)	−0.44 (0.014)
NVA – DES	0.66 (< 0.001)	0.24 (0.069)	0.44 (0.014)
NVA – SE	0.82 (< 0.001)	0.10 (0.445)	−0.12 (0.531)
EOM – DES	−0.50 (< 0.001)	0.08 (0.528)	−0.16 (0.396)

Pair	Baseline, pooled (n = 60)	Change, partial (controlling for group)	Change, yoga group (n = 30)
EOM – SE	−0.20 (0.117)	−0.04 (0.770)	−0.09 (0.627)
DES – SE	0.35 (0.007)	0.06 (0.638)	0.09 (0.646)

VA and NVA are in logMAR (higher values = poorer acuity); a higher DES score means more strain; a higher SE means more hyperopia.

3.5 Influence of Gender, Diet, Physical Activity and Media Use (Exploratory)

Gender, diet, physical activity and media addiction had no significant main effect on any outcome once group and baseline values were taken into account (factor main effects, all $p \geq 0.115$; Table 7). The group × factor interactions were not significant for AA, VA, NVA, EOM or DES (all $p \geq 0.083$), so none of these factors significantly changed the size of the yoga effect on visual function or eye strain (**Figure 5**). The only nominally significant interaction among the 24 tested was between group and gender for SE ($F(1, 55) = 4.34$, $p = 0.042$): the adjusted yoga effect on SE was +0.018 D in boys and −0.018 D in girls, and neither was significant ($p = 0.149$ and 0.161); one p-value below 0.05 would be expected by chance among 24 tests. The yoga effect was significant in every subgroup for AA, NVA, EOM and DES, and for VA in every subgroup except children with low media addiction (n = 11/15; −0.024 logMAR, $p = 0.068$); for SE it was not significant in any subgroup.

Gender. Boys and girls in the yoga group gained similar AA (1.19 vs 1.07 D); compared with controls of the same gender, the adjusted effect was 1.19 D in boys and 0.87 D in girls (interaction $F(1, 55) = 1.39$, $p = 0.244$). The fall in DES score tended to be larger in boys than in girls (adjusted effect −6.3 vs −3.5 points; interaction $F(1, 55) = 2.81$, $p = 0.100$), and effects on VA, NVA and EOM were similar in both (interaction $p \geq 0.86$).

Diet. Children with an eye-healthy diet and those with no specific diet benefited equally (all interaction $p > 0.1$). The largest, non-significant difference was in EOM excursion (adjusted effect 0.60 vs 0.95 mm; $p = 0.139$).

Physical activity. Children with low physical activity tended to gain more accommodation from yoga than active children (adjusted effect 1.29 vs 0.86 D; interaction $F(1, 55) = 2.51$, $p = 0.119$) and more EOM excursion (0.97 vs 0.66 mm; $p = 0.212$), while effects on VA, NVA, DES and SE were similar ($p > 0.5$).

Media addiction. Children with high media addiction tended to benefit more in AA (1.20 vs 0.78 D; $p = 0.142$), NVA (−0.069 vs −0.043 logMAR; $p = 0.083$) and eye strain (−6.3 vs −3.7 points; $p = 0.157$).

In the multivariable ANCOVA (Table 8), group allocation was the only significant predictor of post-programme AA, VA, EOM and DES (all $p < 0.001$). For NVA, older age also predicted slightly better post-programme acuity (−0.006 logMAR per year; 95% CI −0.011 to −0.0003; $p = 0.040$) in addition to group ($p < 0.001$). For SE, no predictor was significant, including group ($p = 0.980$). Gender, diet, physical activity and media addiction did not predict any outcome (all $p \geq 0.10$). The models explained 59–93% of the variance in post-programme values.

Table 7. Change in Each Group by Gender, Diet, Physical Activity and Media Addiction, with Two-Way ANCOVA Results

Factor / level (n yoga/control)	AA, D	VA, logMAR	NVA, logMAR	EOM, mm	DES score	SE, D
Gender						
Boys (16/15)	1.19/0.03	−0.041/−0.009	−0.065/−0.007	0.91/0.30	−6.6/−0.7	0.001/−0.019
Girls (14/15)	1.07/0.16	−0.034/0.008	−0.059/−0.001	1.00/0.10	−5.0/−1.6	−0.006/0.017
Main effect, p	0.943	0.131	0.440	0.463	0.537	0.115
Interaction, F (p)	1.39 (0.244)	0.01 (0.911)	0.03 (0.866)	0.02 (0.885)	2.81 (0.100)	4.34 (0.042)

Factor / level (n yoga/control)	AA, D	VA, logMAR	NVA, logMAR	EOM, mm	DES score	SE, D
Diet						
Eye-healthy diet (15/14)	1.09/0.15	−0.036/−0.003	−0.057/−0.006	0.90/0.29	−5.9/−1.6	0.003/0.006
No specific diet (15/16)	1.18/0.04	−0.040/0.001	−0.067/−0.003	1.00/0.12	−5.8/−0.8	−0.008/−0.008
Main effect, p	0.572	0.388	0.781	0.300	0.165	0.378
Interaction, F (p)	0.31 (0.577)	0.26 (0.613)	0.81 (0.373)	2.26 (0.139)	0.54 (0.464)	0.09 (0.762)
Physical activity						
High activity (20/18)	1.04/0.18	−0.038/−0.001	−0.062/−0.007	0.80/0.17	−5.7/−0.7	−0.007/−0.004
Low activity (10/12)	1.34/−0.04	−0.038/0.000	−0.062/0.000	1.25/0.25	−6.1/−1.8	0.005/0.003
Main effect, p	0.912	0.672	0.550	0.214	0.853	0.228
Interaction, F (p)	2.51 (0.119)	0.08 (0.783)	0.18 (0.669)	1.60 (0.212)	0.28 (0.597)	0.14 (0.712)
Media addiction						
Low media (11/15)	0.86/0.11	−0.035/−0.003	−0.049/−0.005	0.82/0.17	−5.1/−1.3	0.006/−0.001
High media (19/15)	1.30/0.07	−0.040/0.001	−0.069/−0.003	1.03/0.23	−6.3/−0.9	−0.008/−0.002
Main effect, p	0.518	0.814	0.261	0.946	0.800	0.449
Interaction, F (p)	2.22 (0.142)	1.24 (0.271)	3.12 (0.083)	0.98 (0.326)	2.06 (0.157)	0.67 (0.415)

Cells show mean change in the yoga group/control group. Main effect, factor main effect; interaction, group × factor interaction; both from ANCOVA with the baseline value as covariate (interaction df = 1, 55).

Table 8. Multivariable ANCOVA of Post-Programme Outcomes: Coefficient (95% CI); p

Predictor	AA, D	VA, logMAR	NVA, logMAR	EOM, mm	DES score	SE, D
Group (yoga vs control)	1.03 (0.74 to 1.31); < 0.001	−0.035 (−0.050 to −0.020); < 0.001	−0.055 (−0.070 to −0.041); < 0.001	0.78 (0.54 to 1.02); < 0.001	−4.87 (−6.54 to −3.20); < 0.001	−0.0002 (−0.018 to 0.018); 0.980
Age (per year)	−0.05 (−0.23 to 0.13); 0.556	0.002 (−0.004 to 0.007); 0.565	−0.006 (−0.011 to −0.0003); 0.040	−0.03 (−0.12 to 0.06); 0.559	−0.12 (−0.73 to 0.50); 0.708	0.002 (−0.005 to 0.008); 0.649
Girls vs boys	−0.03 (−0.32 to 0.26); 0.828	0.013 (−0.003 to 0.028); 0.101	0.005 (−0.009 to 0.020); 0.472	−0.13 (−0.38 to 0.12); 0.295	0.79 (−0.90 to 2.49); 0.352	0.011 (−0.007 to 0.029); 0.212

Predictor	AA, D	VA, logMAR	NVA, logMAR	EOM, mm	DES score	SE, D
No specific diet vs eye-healthy diet	−0.11 (−0.41 to 0.19); 0.472	0.010 (−0.006 to 0.026); 0.208	−0.003 (−0.018 to 0.013); 0.711	−0.15 (−0.40 to 0.10); 0.243	1.36 (−0.39 to 3.11); 0.124	−0.005 (−0.023 to 0.014); 0.625
Low vs high physical activity	0.01 (−0.29 to 0.30); 0.963	0.003 (−0.013 to 0.018); 0.712	0.002 (−0.014 to 0.017); 0.819	0.16 (−0.10 to 0.41); 0.227	0.28 (−1.54 to 2.10); 0.757	0.010 (−0.009 to 0.028); 0.289
High vs low media addiction	0.07 (−0.24 to 0.37); 0.653	−0.002 (−0.017 to 0.013); 0.798	−0.008 (−0.023 to 0.006); 0.271	−0.001 (−0.25 to 0.25); 0.992	0.30 (−1.42 to 2.02); 0.728	−0.006 (−0.024 to 0.012); 0.493
Model R^2	0.72	0.66	0.85	0.59	0.60	0.93

Each model also includes the baseline value of the outcome (df = 52). Coefficients are in the units of the outcome.

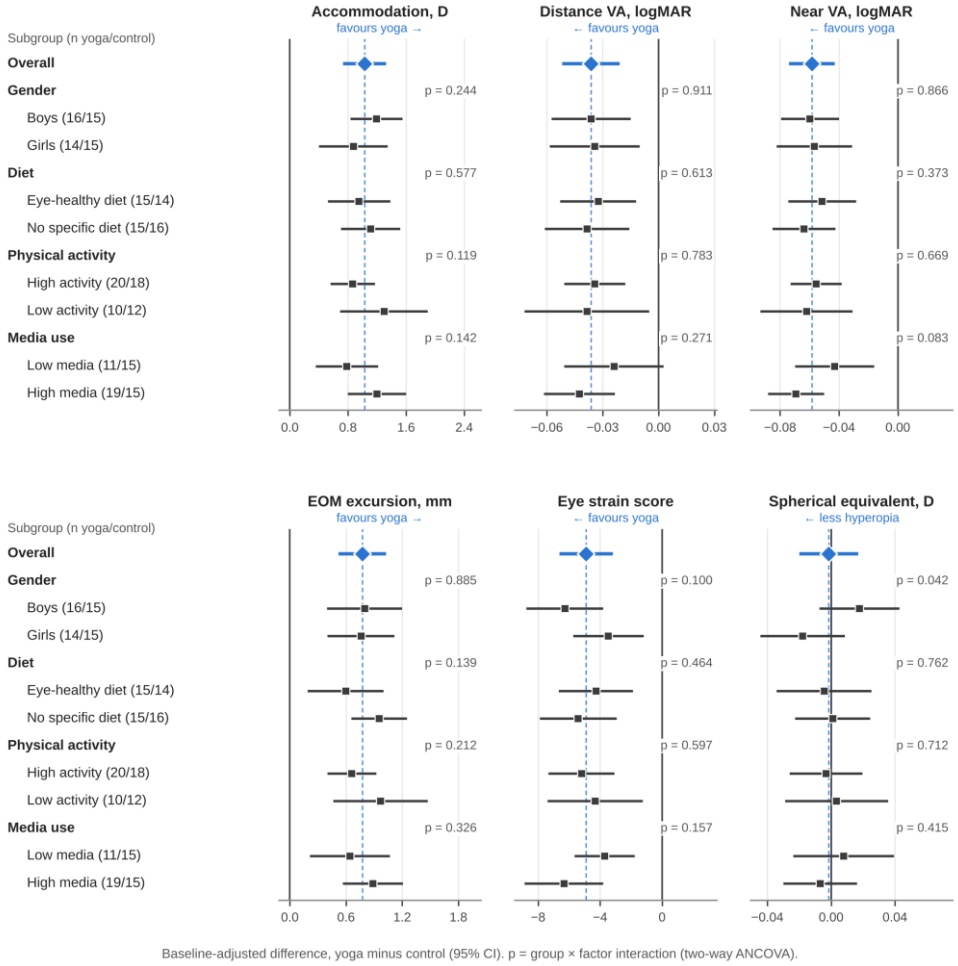


Figure 5. Baseline-adjusted effect of yoga (yoga minus control, 95% CI) overall and within subgroups of gender, diet, physical activity and media use, for each of the six outcomes. p values are for the group × factor interaction.

3.6 Robustness Checks

For AA, VA, NVA, EOM and DES, every between-group result held in the rank-based ANCOVA, the Mann–Whitney test on change scores and the group × time interaction of the mixed ANOVA (all $p < 0.001$), and SE did not differ by any of these methods ($p = 0.74$, 0.91 and 0.88). Adjusting additionally for age and gender gave almost the same differences: AA 1.04 D (0.76

to 1.32), VA −0.036 logMAR (−0.051 to −0.022), NVA −0.056 logMAR (−0.071 to −0.042), EOM 0.78 mm (0.54 to 1.02) and DES −4.9 points (−6.5 to −3.2), all $p < 0.001$; and SE −0.001 D (−0.019 to 0.016; $p = 0.87$).

3.7 Discussion

In this randomised trial of 60 school children with low hyperopia, a 12-week yoga and kriya programme improved accommodation, near and distance acuity, ocular excursion and eye-strain scores compared with no intervention, and refraction did not change. By partial η^2, the largest effect was on near visual acuity, followed by amplitude of accommodation, EOM excursion, digital eye strain and distance visual acuity. Each of these results held in the rank-based ANCOVA, the Mann–Whitney test and the group × time interaction, and after adjustment for age and gender or for all the lifestyle factors together, whereas SE did not differ between groups by any method. These are changes in functional measures and in symptom scores. They were not accompanied by any change in refractive error, so they do not show that yoga reduces hyperopia.

Accommodation. Baseline AA (mean 10.6 D) was about 1.1 D below Hofstetter's age-expected minimum, which averaged 11.7 D for these ages (Hofstetter, 1950). It was well below the mean of 15.5 D reported with the push-up method in a large sample of schoolchildren (Castagno et al., 2017). Part of this shortfall is expected in uncorrected hyperopia. Because AA was measured without spectacles, a hyperopic eye uses part of its accommodation to overcome its refractive error before it can focus on the near target. The push-up value therefore underestimates the true amplitude by roughly the amount of hyperopia, which averaged +0.75 D here. Hofstetter's norms may also overstate expected AA in Tamil Nadu children (Hussaindeen et al., 2017a). After the programme, the yoga group's mean AA reached the age-expected minimum while SE stayed the same, so the gain reflects accommodative function rather than a reduction in hyperopia. A learning effect alone is unlikely, because controls were tested twice and their AA did not change. However, near-point AA depends on the child reporting blur, so motivation or expectation in the yoga group may have contributed.

Near and distance acuity. The gain in near acuity fits the gain in accommodation. In an uncorrected hyperopic eye, near acuity depends on how much accommodation is left after the hyperopia has been overcome. Even so, the mean change of about 0.06 logMAR is within the test–retest variation of letter charts. Changes of 0.1 logMAR or less cannot be reliably distinguished from no change even on ETDRS charts (Rosser et al., 2003), so individual changes should be interpreted cautiously. Distance VA improved by only about two letters. In whole Snellen lines, 9 children in the yoga group (30%) gained a line, against 3 controls (10%; Fisher $p = 0.104$), and none lost a line, against 5 controls (17%; $p = 0.052$), so neither difference was significant. The control group, with equal numbers reading more and fewer letters (11 each), shows what that variation looks like. Because the examiner did not know group allocation, examiner bias is unlikely, but greater effort or better fixation in trained children could contribute. Cycloplegic SE did not change in either group, consistent with earlier evidence that eye exercises do not alter refractive error (Tang et al., 2023). The acuity findings should therefore not be read as evidence that yoga corrects hyperopia.

Eye strain and ocular excursion. The 4.9-point lower DES score is in the same direction as earlier studies in which yoga reduced visual discomfort in adult computer users (Telles et al., 2006) and yoga ocular exercises reduced eye fatigue in students (Gupta and Aparna, 2020), although both had important limitations. Digital eye strain is partly driven by accommodative stress (Sheppard and Wolffsohn, 2018), and uncorrected hyperopia adds to that stress, because the hyperopic eye must accommodate more during near work. The change scores support this link: larger AA gains went with larger falls in strain after the programme, and in the yoga group so did larger gains in near acuity, although AA and strain were not significantly related at baseline. Children with greater ocular excursion also reported less strain at baseline. Trataka, in which the eyes hold a steady fixation on a candle flame at changing distances, occupied 30 of the roughly 50 practice minutes and is the most plausible contributor to the gains in accommodation and ocular excursion, but the design cannot separate the effects of the individual practices. Controls also improved slightly in DES (−1.1 points) and EOM (+0.20 mm), which may reflect regression to the mean, familiarity with the tests or changes over the school term.

Statistical significance and clinical importance. All between-group differences except that for SE remained significant after Holm correction for six outcomes, but a small p-value shows only that a difference is unlikely to be due to chance; it does not show that the difference matters to a child. Judged against the benchmarks in Section 2.6, the clinical weight of the effects varies. The DES difference of −4.9 points (95% CI −6.5 to −3.3) was about 2.6 times the half-SD benchmark of 1.9 points, and the whole confidence interval lay beyond it, but it represents only 3.6% of the possible score range on an unvalidated

questionnaire, so its meaning for children's comfort is uncertain. The AA difference of 1.03 D (95% CI 0.76 to 1.30) is a group-average effect; even its upper confidence limit is below the 1.50 D proposed as the minimum significant change between repeated push-up measurements in an individual (Rosenfield and Cohen, 1996), so a gain of this size could not be confirmed in a single child. The NVA and distance VA differences were about three and two letters, and the largest differences compatible with the data (the confidence limits, 3.6 and 2.5 letters) were still below the five-letter, or 0.10 logMAR, change that can be distinguished from test–retest variation (Rosser et al., 2003). The EOM difference of 0.77 mm corresponds to about one and a half steps of the 0.5 mm scale on which excursion was recorded. For refraction, the 95% CI of the SE difference (−0.019 to 0.016 D) excludes any effect larger than 0.02 D, less than a tenth of the 0.25 D step used in clinical refraction, so the absence of an effect on hyperopia is itself an informative result. Taken together, the trial provides consistent statistical evidence of changes in functional and symptom measures, but their clinical importance for individual children remains to be established.

Responder analyses. In exploratory analyses with thresholds chosen after data collection, the yoga group improved by 11–13% in accommodation, ocular excursion and eye-strain score, against 1–3% in controls, and gained about two letters of distance acuity and three letters of near acuity, against almost none in controls. Expressed as numbers needed to treat, one additional child gained at least 1 D of accommodation for every two children trained (NNT 1.8; 95% CI 1.4 to 2.8), one additional child gained a line of near acuity (≥ 0.10 logMAR) for every four (NNT 3.8; 2.2 to 10.2), and one additional child had a fall in DES score of at least half a standard deviation for every two (NNT 2.1; 1.6 to 4.3). The most clinically relevant change may be in accommodation: the average near point moved about 0.9 cm closer, and the proportion of children with AA below the age-expected minimum fell from 97% to 43% in the yoga group, compared with no change in controls (97% before and after; RR 0.45; NNT 1.9). However, accommodative insufficiency is usually defined as AA at least 2 D below the age-expected minimum (Castagno et al., 2017). Only five children met that definition at baseline, so this sample did not, on the whole, have accommodative insufficiency. These would be large effects for a non-pharmacological school programme if confirmed, but the responder thresholds were set after the data were seen, the confidence intervals are wide, the gain in distance acuity lines was not significant, and the outcomes are functional measures rather than diagnoses, so they should be confirmed prospectively.

Gender, diet, physical activity and media use. Some of these factors were related to children's eye status at the start, but none clearly changed how much they gained. Physically active children had less eye strain at baseline, and children eating an eye-healthy diet tended to have less strain and had better distance and near acuity. The diet difference in acuity may partly reflect the slightly lower hyperopia of these children (+0.72 vs +0.78 D; $p = 0.074$), because acuity was closely related to SE. Children with high media addiction had slightly lower AA and smaller EOM excursion, although neither difference was significant, and boys and girls did not differ. In the two-way and multivariable ANCOVA models, none of these factors predicted the post-programme outcome or significantly modified the yoga effect on visual function or eye strain. The single nominal interaction, between gender and group for SE, involved small subgroup estimates in opposite directions, neither of them significant, and is likely to be a chance finding among 24 interaction tests; the association of older age with better post-programme near acuity in the multivariable model ($p = 0.040$) is also a single nominal result. The non-significant trends mostly ran in one direction: children with high media addiction tended to gain more on every functional outcome, less active children tended to gain more accommodation and ocular excursion, and children who started with lower AA, poorer distance acuity or smaller EOM excursion gained more, suggesting that those with the most room to improve may benefit most. The benefit therefore appears to extend to boys and girls and across diet, activity and media-use levels, which supports offering the programme to whole classes rather than selected children. The programme needs 50 minutes a day, 4 days a week and little equipment, and could complement, not replace, spectacle correction where indicated and screen-time advice.

Relevance to other and congenital eye conditions. These findings apply to school children with low hyperopia and no other eye disease. Only low hyperopia was studied and children with ocular disorders were excluded, so the trial provides no evidence for higher hyperopia, anisometropia, refractive accommodative esotropia, amblyopia, congenital cataract, congenital glaucoma, infantile strabismus or nystagmus. These conditions depend on timely standard treatment (spectacles or other optical correction, surgery, occlusion or medical therapy), and delaying it can cause permanent visual loss, so yoga practices should not be offered as an alternative. The functional pattern seen here, with better accommodation and ocular excursion and less strain, does suggest two lines of future research: yoga-based eye practices as a supervised adjunct for non-strabismic accommodative and vergence anomalies, which are common among school children in Tamil Nadu (Hussaindeen et al., 2017b), and as an adjunct to standard

care in selected children once a congenital condition has been treated, under ophthalmologist oversight. The safety of prolonged candle gazing has not been studied in these groups and would need to be established first.

3.8 Strengths and Limitations

The strengths of this trial are random allocation, an outcome assessor blinded to group, high attendance with no loss to follow-up, ophthalmologist examination, cycloplegic refraction before and after the programme, outcomes covering visual function, refraction and symptoms, and an analysis that adjusted for baseline values and covariates, controlled the family-wise error rate across the six outcomes and was confirmed with non-parametric methods.

It also has limitations. The sample was small: with 30 children per group, only large effects ($d \geq 0.74$) could be detected, several confidence intervals are wide, and the subgroup analyses had little power. All children came from schools in a single city, Chennai, so the findings may not apply to children in other regions, school systems or climates. The range of hyperopia studied (+0.50 to +1.00 D) is narrow and often regarded as within normal limits at these ages, so the findings may not apply to children with higher hyperopia, who usually need spectacles. The subgroup, covariate, correlation and responder analyses were exploratory and not corrected for multiple testing, and the responder thresholds were chosen after data collection. The same investigator generated the allocation sequence, enrolled the children, assigned them to groups and delivered the intervention, so allocation was not concealed and the trial was not conducted independently of the intervention team.

Expectancy effects are a particular concern. Children could not be blinded to yoga, and AA (which depends on the child reporting blur), distance and near acuity (which depend on effort and on guessing near threshold) and the DES questionnaire all rely on the child's responses, so expectation, motivation or a wish to please the investigators may have enlarged the differences, even though the examiner was unaware of group allocation. The control group received no activity matched for contact time, so attention may explain part of the effect, particularly on symptoms. The DES questionnaire was developed for this study and has not been validated in children; its reliability, responsiveness and minimal important difference are unknown. At baseline the DES score was correlated with NVA ($\varrho = 0.66$) and EOM excursion ($\varrho = -0.50$), which offers limited support for its construct validity, but this does not replace formal validation, and the size of the symptom effect should be interpreted cautiously. The lifestyle questionnaire and the lifestyle classifications were also study-specific. AA was measured without correction, which underestimates amplitude in hyperopic eyes. Distance and near acuity were scored letter by letter, but the observed changes were within test–retest variation, and the type of acuity chart and the near testing distance were not recorded. EOM excursion was measured with a hand-held millimetre ruler at the limbus, a simple clinical method of limited precision, so the EOM result reflects a change in this recorded measure rather than definitive evidence of improved extraocular muscle function. Outcomes were measured only once, at the end of the 12-week programme, so it is not known whether the changes persist after practice stops. Screen time, outdoor time and daily routine were not controlled. No test–retest reliability data were available for the AA, NVA, EOM and DES measurements in this sample, and the analyses were specified after data collection without a registered analysis plan. Finally, the trial was not prospectively registered, which limits protection against selective reporting.

For these reasons the results should be regarded as preliminary. Before such a programme can be recommended, it should be tested in larger, adequately powered multicentre trials conducted by investigators independent of those delivering the intervention, with prospective registration, concealed allocation and a pre-specified primary outcome. These trials should include an attention-matched control activity, a symptom questionnaire validated in children, objective measures of accommodation (for example, accommodative response measured with an open-field autorefractor) taken with and without refractive correction, standardised logMAR charts at recorded distances and lighting, and follow-up of at least several months after the programme ends to assess whether any benefit persists.

4. CONCLUSION

In children aged 11 to 15 years with low hyperopia, a 12-week yoga and kriya programme (4 sessions a week, centred on candle trataka) improved amplitude of accommodation, extraocular muscle excursion and a study-specific eye-strain score compared with no intervention, and produced small gains in near and distance visual acuity of about three and two letters, within normal test–retest variation. Refractive error did not change, so the findings concern functional measures and symptoms, not correction of hyperopia. The differences were statistically robust, but their clinical importance for individual children is uncertain. Larger, independently conducted multicentre trials with concealed allocation, an attention-matched control group, a validated symptom

questionnaire, objective measures of accommodation with and without correction, and follow-up beyond the end of the programme are needed.

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AUTHOR CONTRIBUTIONS

K. Sreedhar Rao: Conceptualization, Methodology, Investigation, Intervention delivery, Randomisation, Data curation, Writing—Original Draft.

D. Uma Maheswari: Supervision, Writing—Review & Editing.

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Subbulakshmi Velusamy: Supervision, Project administration, Writing—Review & Editing.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS STATEMENT

The study was approved by the Institutional Human Ethics Committee of Meenakshi Academy of Higher Education and Research (MAHER) on 22 April 2024. The committee is registered with the Department of Health Research (EC/New/INST/2023/3553) and the Central Drugs Standard Control Organisation (ECR/1906/INST/TN/2023). Written informed consent was obtained from the parents of all participants, and all children gave their assent to take part. The study followed the Declaration of Helsinki. The trial was not prospectively registered in a clinical trial registry.

DATA AVAILABILITY STATEMENT

The anonymised participant-level dataset, a data dictionary and the analysis code are provided as Supplementary Material S1. The eye strain questionnaire is available from the corresponding author on request.

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