Research Article

# Blue Blocking Filters and Sleep Scores in Myopic Children

Irene Sophia Joseph[1]*, Reetu Malhotra[2], Anupama Prasan Rao[3] , Kaushik Murali[4], Vandana Kamath[5]

[1]Department of Health Sciences, Chitkara University, Punjab, India.
[2]Chitkara University Institute of Engineering and Technology, Chitkara University, Punjab, India.
[3]Diploma in Ophthalmology (DO),University of Mumbai, India.
[4]Ophthalmology Department , Sankara Eye Hospital , Bangalore, India.
[5]Vandana Kamat, Sankara College of Optometry, Bangalore, India.

**Corresponding author:** Irene Sophia Joseph, E-mail: irenesj@gmail.com.

**ABSTRACT**

**Objective:** To determine whether wearing high blue-blocking spectacle filters for two hours before bedtime improves sleep in myopic children and young adolescents already treated with low-dose atropine.

**Methods:** A prospective, double-masked, parallel-group controlled trial was carried out at a tertiary eye hospital in Bengaluru, India, between 2023 and 2024. Children aged 8 to 13 years using atropine 0.01% eye drops were allocated alternately to an orange clip-on filter blocking 99% of light between 455 and 500 nanometres or to a visually matched yellow placebo filter, worn for two hours before habitual bedtime for 12 months. Sleep was assessed at baseline, 6 and 12 months with seven-day wrist actigraphy (sleep score, 0 to 100) and the parent-reported Children's Sleep Habits Questionnaire. Between-group differences were tested with analysis of covariance adjusted for baseline values.

**Results:** Fifty children (25 per group) completed follow-up. At 12 months the actigraphiy sleep score had risen by a mean of 5.1 points with the blue-blocking filter and by 0.2 points with the placebo filter; the baseline-adjusted means were 89.8 and 84.5 ($p<0.001$). Questionnaire scores, where lower values indicate fewer sleep problems, fell by 4.8 and 3.1 points respectively; adjusted means were 45.4 and 48.5 ($p<0.001$). Differences were already present at 6 months. No adverse events attributable to the filters were recorded.

**Conclusion:** Evening blue-blocking filters added to low-dose atropine produced a sustained improvement in objective and parent-reported sleep in myopic children, supporting their use as a simple adjunct to myopia care in this age group.

**Keywords:** Myopia; Sleep; Child; Adolescent; Eyeglasses; Circadian Rhythm.

## Introduction

Roughly one person in three is already myopic, and modelling suggests that half the world's population will be by 2050.[1] Myopia typically appears in the early school years and advances most quickly between about 8 and 13 years, which makes late childhood and early adolescence the period in which intervention counts most. Indian school surveys show lower prevalence than East Asian ones, but the figures are climbing, especially in cities.[2] Myopia is now viewed partly as a condition of lifestyle, and sleep is one of the daily behaviours most strongly linked to it.

The body clock is informed about ambient light by a small group of retinal ganglion cells that contain the photopigment melanopsin. These cells are most responsive to light of about 480 nm and signal the suprachiasmatic nucleus, which in turn controls the release of melatonin by the pineal gland.[3] Light in the evening therefore lowers melatonin and pushes the clock later. Young children are particularly susceptible: an hour of bright evening light reduced melatonin by close to 90% in preschoolers, and levels stayed low after the light was turned off.[4,5] Screens and white LED lamps emit a large share of their energy in this blue band, and using screens before bed is repeatedly linked with falling asleep later, sleeping less and feeling sleepy during the day.[6]

Myopic children seem to sleep less well than other children. In Japan, highly myopic young people retired later, slept for less time and rated their sleep as worse than non-myopic peers.[7] Myopic young adults have a later evening rise in melatonin and produce less of the hormone overall.[8] Among Chinese schoolchildren, habitually going to bed after 21:30 was associated with being myopic, with becoming myopic within two years and with faster progression.[9] Taken together, these findings point to a shared circadian route linking evening light, poor sleep and myopia. School-aged children need nine to twelve hours of sleep, yet the clock drifts later around puberty while school start times do not, so this group is especially exposed.

Insufficient or mistimed sleep at this age is linked with daytime sleepiness, irritability, weaker attention and poorer school performance, so a safe way of protecting sleep in myopic children would bring benefits well beyond the eye. Clinicians who manage myopia are also frequently asked by parents whether screen use in the evening matters, and they currently have little direct evidence with which to answer.

Lenses that filter short wavelengths can cut the evening signal reaching melanopsin cells. In adults, amber lenses worn for two to three hours before bed improved rated sleep quality,[10] lengthened sleep in people with

insomnia[11] and brought sleep onset forward in delayed sleep phase disorder.[12] Two weeks of short-wavelength filtering increased measured sleep and night-time melatonin in healthy adults,[13] and blue blockers blunted the alerting effect of evening screen use in teenage boys.[14] A meta-analysis of crossover trials in adults, however, found only small actigraphiy benefits.[15] Evidence in children is scarce: one crossover study of lenses cutting 40% of blue light in Japanese schoolboys showed an earlier sleep phase and less daytime irritability, without any change in salivary melatonin.[16] Blue-filtering spectacles have also been tested for slowing myopia, with unclear results,[17] but none of these trials measured sleep.

This study asked whether a high blue-blocking clip-on filter, worn for the two hours before bedtime by myopic children already using atropine 0.01%, would improve objectively recorded and parent-reported sleep over 12 months compared with a placebo filter of identical appearance.

## Methods

**Design and setting**

We conducted a 12-month, double-masked, parallel-group controlled trial with alternate allocation at the paediatric ophthalmology clinic of Sankara Eye Hospital, Bengaluru, India, recruiting during 2023 and 2024. Sleep was a prespecified secondary outcome; the trial's primary outcomes were refraction and axial length, reported separately.

Participants

Children aged 8 to 13 years were eligible if, under cycloplegia, the spherical error was between −0.50 and −6.00 D with no more than 2.00 D of astigmatism in either eye, and corrected acuity was 6/9 or better in each eye. Every child had begun atropine 0.01% drops for myopia during the preceding two years as part of routine hospital care. Children also needed clear media, a healthy fundus, intraocular pressure of 10–21 mmHg, no strabismus on cover testing, no systemic condition affecting eye growth, and willingness to wear the clip-on for the whole year. Exclusion criteria were ocular or systemic disease, poor understanding of the study language, likely poor adherence and residence more than 50 km from the hospital.

Allocation and masking

Eligible children were assigned in strict alternation, the first to the active filter, the second to the placebo and so on. One investigator handled allocation and dispensing and had no role in measurement. Two other optometrists, unaware of group assignment, carried out every assessment, including issuing and collecting actigraphy devices and giving out questionnaires. Families were not told which filter they had, and both clip-ons had the same frame, size and fit.

Intervention

The active clip-on was orange polycarbonate that removed 99% of light from 455 to 500 nm, the band to which melanopsin responds most. The placebo was yellow polycarbonate of the same shape; it cut light below about 420 nm but passed more than 90% of light above 460 nm, leaving the melanopsin band essentially untouched. In a pilot with 15 young myopic adults, acuity and contrast sensitivity through the orange clip-on matched unfiltered values, and reading was slightly quicker through the yellow one.

Each evening a parent attached the clip-on to the child's own spectacles two hours before the usual bedtime and took it off when the child went to sleep. All children kept using one drop of atropine 0.01% in each eye roughly 30 minutes before sleep. Both groups were given identical advice: under two hours of recreational screen use and at least two hours outdoors daily. Parents kept a daily wear checklist, and staff phoned families at months 1, 3, 5, 7, 9 and 11 to encourage adherence and note any adverse effects.

At each visit the masked examiners also repeated the routine eye examination, including cycloplegic refraction, optical biometry and assessment of binocular function, and asked about any new eye or general symptoms, changes in medication, outdoor time, screen habits and any parental concerns about the child's sleep or behaviour. Parents' wear checklists were reviewed at every visit.

Sleep measures

Sleep was assessed in the same way at baseline, 6 months and 12 months, using one objective and one parent-reported measure so that each could be checked against the other.

**Actigraphy.** At each visit the child received a wrist device, with spoken and written instructions for child and parent, and wore it without interruption for the next seven days. The manufacturer's validated algorithm combined sleep duration, sleep stages, breathing during sleep, regularity and resting heart rate into a score from 0 to 100, higher meaning better sleep. Recordings were screened on return and repeated when they covered fewer than five nights or showed over two hours of artefact in a 24-hour period. The weekly mean score was analyzed.

**Questionnaire.** Parents filled in the 33-item Children's Sleep Habits Questionnaire (CSHQ), which rates bedtime resistance, delay in falling asleep, sleep duration, sleep anxiety, night waking, parasomnias, disordered breathing and daytime sleepiness on a three-point frequency scale.[18] Totals range from 33 to 99, higher totals mean more problems, and a score above 41 is used to flag clinically relevant disturbance.[18] The instrument has been checked against polysomnography and actigraphy in school-aged children,[19] and wrist actigraphy is an accepted tool for recording children's sleep at home.[20] The masked examiner confirmed that every item had been answered before the family left.

Adverse ocular events, visual or comfort complaints and withdrawals were logged at visits and during calls.

Sample size and analysis

The sample size was set for the trial's main biometric outcome: for an effect size of 0.63 with 80% power and two-sided alpha of 0.05, 25 children per group were needed, and 34 per group were enrolled to cover losses.

Data were analyzed in Jamovi software. The Shapiro–Wilk test was used to check normality, and baseline values were compared with t-tests (Welch-corrected when variances differed). Within each group, change over the three visits was examined with the Friedman test and, when significant, with Bonferroni-adjusted Wilcoxon signed-rank tests. Change scores were compared between groups with the Mann–Whitney U test. Because baseline questionnaire scores differed between groups, the principal comparison at each follow-up was an analysis of covariance (ANCOVA) with the baseline value as covariate, reporting partial eta squared. Twelve-month changes were also compared between boys and girls within each group. Two-tailed $p<0.05$ was considered significant.

**Ethics**

The study complied with the Declaration of Helsinki and Indian Council of Medical Research guidelines, and was approved by the ethics committees of Sankara Eye Hospital, Bengaluru (SHE/BLR/EC/2023/92) and Chitkara University, Punjab (IHEC/DHR/CU/PB/23/179). Parents gave written consent and children gave assent; families could withdraw at any time.

## Results

**Participants**

Of 102 children screened, 68 were enrolled (34 per group). Nine in each group did not finish: in the blue-blocking group, two moved to orthokeratology, five were lost to follow-up and two stopped wearing the filter; in the placebo group, seven were lost to follow-up and two began peripheral-defocus spectacles. The analysis therefore included 50 children, 25 per group.

Age, sex and baseline actigraphiy score were similar in the two groups (Table 1). The blue-blocking group was more myopic, had longer eyes and started with lower (better) questionnaire scores, so follow-up values were adjusted for baseline.

**Table 1.** Baseline characteristics of children who completed the study

| Characteristic | Blue-blocking filter (n = 25) | Placebo filter (n = 25) | p |
|---|---|---|---|
| Age, years, mean (SD) | 10.56 (1.94) | 10.64 (1.83) | 0.83 |
| Sex, boys / girls | 12 / 13 | 13 / 12 | — |
| Spherical equivalent, D, mean (SD) | −4.67 (1.43) | −3.93 (1.55) | 0.02 |
| Axial length, mm, mean (SD) | 25.31 (0.83) | 24.85 (1.06) | 0.02 |
| Actigraphic sleep score, 0–100, mean (SD) | 85.17 (4.81) | 83.85 (6.18) | 0.24 |
| CSHQ total score, mean (SD) | 48.68 (3.73) | 53.04 (3.74) | <0.001 |

CSHQ: Children's Sleep Habits Questionnaire (higher scores indicate more sleep problems). SD: standard deviation. Independent t-tests.

Change within each group

With the blue-blocking filter, the median sleep score went from 85.6 to 88.9 at 6 months and 89.3 at 12 months (Friedman $\chi^2 = 94.53$, $p<0.001$), increasing significantly in each six-month interval (Table 2). With the placebo it barely moved: 83.4, 83.7 and 84.0 ($\chi^2 = 2.56$, $p = 0.28$).

In post hoc tests, the active group gained a median of 3.0 points in the first six months and a further 1.5 points in the second, for a median one-year rise of 5.0 points (all $p<0.001$ after Bonferroni correction). Because the overall Friedman test was not significant in the placebo group, no interval tests were carried out for its sleep score.

Questionnaire scores declined in both groups, from a median of 48 to 45 and then 44 with the active filter ($\chi^2$ = 80.82, p<0.001) and from 54 to 53 and then 50 with the placebo ($\chi^2$ = 37.38, p<0.001); each six-month step was significant in both groups.

**Table 2.** Sleep outcomes at each visit and change from baseline

| Outcome and group | Baseline, median (IQR) | 6 months, median (IQR) | 12 months, median (IQR) | Change at 6 months, mean (SD) | Change at 12 months, mean (SD) |
|---|---|---|---|---|---|
| Sleep score, blue-blocking | 85.6 (81.3–88.4) | 88.9 (85.2–92.1) | 89.3 (86.4–94.6) | +3.57 (3.65) | +5.12 (4.02) |
| Sleep score, placebo | 83.4 (80.4–87.1) | 83.7 (81.4–87.6) | 84.0 (82.0–87.8) | +0.50 (3.28) | +0.17 (4.12) |
| CSHQ, blue-blocking | 48 (47–52) | 45 (43–48) | 44 (41–45) | −3.40 (2.67) | −4.76 (2.75) |
| CSHQ, placebo | 54 (51–56) | 53 (50–55) | 50 (50–54) | −1.36 (2.52) | −3.08 (3.89) |

Sleep score: actigraphiy score from 0 to 100 (higher is better). CSHQ: Children's Sleep Habits Questionnaire (lower is better). IQR: interquartile range. Between-group comparison of change scores (Mann–Whitney U): sleep score p<0.001 at 6 and 12 months; CSHQ p<0.001 at 6 months and p = 0.007 at 12 months.

Between-group comparisons

Over the year, the sleep score rose by a mean of 5.1 points with the active filter against 0.2 points with the placebo (p<0.001), and the CSHQ total dropped by 4.8 and 3.1 points (p = 0.007). After baseline adjustment both outcomes still favoured the active filter at each visit (Table 3). The adjusted gap in sleep score grew from 3.4 points at 6 months to 5.4 points at 12 months (partial $\eta^2$ = 0.35); the adjusted CSHQ gap was 3.3 and then 3.2 points.

**Table 3.** Baseline-adjusted comparison of sleep outcomes (ANCOVA)

| Outcome | Visit | Adjusted mean, blue-blocking | Adjusted mean, placebo | F (df) | p | Partial $\eta^2$ |
|---|---|---|---|---|---|---|
| Sleep score | 6 months | 88.26 | 84.82 | 29.94 (1, 97) | <0.001 | 0.24 |
| Sleep score | 12 months | 89.83 | 84.46 | 51.98 (1, 97) | <0.001 | 0.35 |
| CSHQ | 6 months | 46.83 | 50.13 | 35.75 (1, 97) | <0.001 | 0.27 |
| CSHQ | 12 months | 45.36 | 48.53 | 19.07 (1, 97) | <0.001 | 0.16 |

ANCOVA: analysis of covariance with the baseline value as covariate. CSHQ: Children's Sleep Habits Questionnaire.

**Sex and safety**

Among children using the active filter, girls improved more than boys on actigraphy (mean +6.34 vs +3.80; p = 0.044), but not on the questionnaire (p = 0.76); no sex difference appeared with the placebo. No adverse ocular events, visual or comfort complaints, or withdrawals were attributed to either filter.

## Discussion

Children aged 8 to 13 with myopia who wore a high blue-blocking clip-on for two hours before bed for a year slept better than those who wore an identical-looking placebo. The advantage was evident on both device-based and parent-reported measure, was apparent by 6 months and, on actigraphy, increased by 12 months. The filter is the most plausible explanation for the difference because every child continued atropine 0.01% and received the same lifestyle advice. To our knowledge, no previous controlled trial has examined the effect of evening blue light filtering on sleep in myopic children receiving standard treatment, nor has any such trial followed these children for a full year. The most telling finding is the actigraphy. Compared to almost no change in the placebo group, children on the active filter gained about five points on the sleep score. While parental reports may be subject to expectations, a wrist device that tracks movement and heart rate for a week is much less likely to be. The adjusted difference also increased between the 6- and 12-month visits, arguing against a short-lived novelty effect and suggesting that the benefit builds with continued use. Both groups got better on the questionnaire. That's to be expected: all families received advice on screens and outdoor time, regular reminder calls and a daily checklist, and being in a study tends to make parents pay more attention to bedtime routines. The yellow placebo took some of the violet light away. But the active group did even better on both visits when the better start was taken into account. This change is of clinical significance. 41 is the normal cut-off for disturbed sleep.[18] Both

groups started out well above that. After a year the median in the active group was down to 44, near the cut-off, while the placebo group was still at 50. The results are in line with the physiology of light in the evening. Melanopsin cells peak at ~480 nm, driving melatonin suppression and downstream circadian timing. [3] The active filter blocked almost all light between 455 and 500 nm, whereas the placebo transmitted most of it. Because young children are highly sensitive to evening light[4,5], and screen time before bed leads to a delay and reduction in sleep[6], removing this band before bed should allow melatonin to rise on time and sleep to commence earlier and be more consolidated. Note that the actigraphy benefit was observed despite both filters being worn for the same two hours, in the same frames and with the same routine. The only systematic difference was the band of light that each removed. The yellow placebo filtered out the violet light below ~420 nm, which contributes little to melanopsin activation, while the orange filter eliminated the blue-cyan band at its peak. If any tinted lens worn at bedtime had improved sleep simply through ritual or groups should have expectation, the two moved together on actigraphy, which they did not. This contrast is an internal control for the spectral hypothesis. Another point is that sleep in the active group continued to improve between 6 and 12 months. Circadian timing adapts to the light environment over days to weeks, but habits around bedtime such as when a child stops using a screen or when lights are dimmed may take longer to settle, and a filter worn every evening could support such gradual change. These findings are consistent with adult studies showing improved sleep quality, longer sleep, and earlier sleep onset with amber or orange lenses10-13 and decreased evening alertness in teenage boys when using blue blockers with screens.[14] The pooled adult crossover data showed only small effects,[15] but those trials typically lasted one to two weeks and involved adults, whose clocks are less sensitive to light than children's. The only similar study in children used lenses that blocked 40% of blue light for two weeks and found an earlier sleep phase without changing the efficiency of actigraphy. The more apparent effect noted here could be attributed to the almost complete disappearance of the 455-500 nm band, a much longer wear time and the poorer baseline sleep of myopic children.[7] This population is critical to adolescent's health. Myopic children sleep less and go to bed later[7] and late bedtimes are associated with myopia onset and progression[9]. Short sleep in this agegroup affects attention, mood and school work. Previous trials of blue-filtering spectacles in myopia have only looked at refraction and eye length.[17] Recording sleep, too, gives a fuller picture of what such lenses do. The intervention was simple to use. Parents attached the clip-on to the existing glasses at a set time each evening, with no complaints of discomfort or adverse events related to the filter. Commonly, people are advised to limit evening screens, but it is difficult to enforce, especially for older children who need devices for homework and social contact.[6] A filter is no substitute for good habits but it lessens the circadian impact of light children are exposed to anyway and the regular reviews already required for children on atropine are a natural opportunity to discuss sleep. The larger actigraphy gain in girls needs to be interpreted with caution as it was one of many subgroup tests and not apparent on the questionnaire. The study has limitations . allocation was random but alternation and the groups were different at baseline in questionnaire score, refraction and eye length, baseline adjustment reduces but cannot remove this bias. The sample was moderate and from a single center in South India. The actigraphy score is a proprietary composite and cannot be directly compared with sleep efficiency or total sleep time in other studies. The circadian mechanism is inferred because melatonin timing was not measured. was reported by the parents, not measured. Finally, the lifestyle advice given to both groups may have improved questionnaire scores in both groups and the contribution of the filter may be harder to separate on that measure. We also did not separate school nights from weekend nights, though sleep timing often differs markedly between these groups in this age. Screen time was reported by families rather than recorded. Future trials need to randomize properly, measure melatonin timing, report standard actigraphy variables and follow children beyond 1 year to see whether better sleep goes with slower myopia progression.

## Conclusion

In myopic children aged 8 to 13 years using atropine 0.01%, a high blue-blocking clip-on worn for two hours before bed improved both actigraphy and parent-reported sleep over 12 months compared with a placebo filter, with benefits visible by 6 months and no adverse events. This low-cost and well tolerated measure can be offered together with advice about screen use and outdoor time in the care of myopic children and young adolescents.

**Declarations**

Acknowledgements: The authors thank the children and families who took part, and the staff of the paediatric ophthalmology clinic at Sankara Eye Hospital, Bengaluru.

Author contributions: Irene Sophia Joseph: study design, data collection, analysis and drafting. Reetu Malhotra: supervision, statistical analysis, critical revision. Anupama Prasan Rao: clinical oversight, critical revision. Kaushik Murali : clinical oversight, critical revision. Vandana Kamath: data collection, analysis and drafting. All authors approved the final version.

Conflict of interest: None declared.
Funding: No external funding.

## References

1.Holden BA, Fricke TR, Wilson DA, Jong M, Naidoo KS, Sankaridurg P, et al. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. Ophthalmology. 2016;123(5):1036-42.
2.Agarwal D, Saxena R, Gupta V, Mani K, Dhiman R, Bhardawaj A, et al. Prevalence of myopia in Indian school children: meta-analysis of last four decades. PLoS One. 2020;15(10):e0240750.
3.Do MT, Yau KW. Intrinsically photosensitive retinal ganglion cells. Physiol Rev. 2010;90(4):1547-81.
4.Akacem LD, Wright KP Jr, LeBourgeois MK. Sensitivity of the circadian system to evening bright light in preschool-age children. Physiol Rep. 2018;6(5):e13617.
5.Hartstein LE, Behn CD, Akacem LD, Stack N, Wright KP Jr, LeBourgeois MK. High sensitivity of melatonin suppression response to evening light in preschool-aged children. J Pineal Res. 2022;72(2):e12780.
6.Hale L, Kirschen GW, LeBourgeois MK, Gradisar M, Garrison MM, Montgomery-Downs H, et al. Youth screen media habits and sleep: sleep-friendly screen behavior recommendations for clinicians, educators, and parents. Child Adolesc Psychiatr Clin N Am. 2018;27(2):229-45.
7.Ayaki M, Torii H, Tsubota K, Negishi K. Decreased sleep quality in high myopia children. Sci Rep. 2016;6:33902.
8.Chakraborty R, Micic G, Thorley L, Nissen TR, Lovato N, Collins MJ, et al. Myopia, or near-sightedness, is associated with delayed melatonin circadian timing and lower melatonin output in young adult humans. Sleep. 2021;44(3):zsaa208.
9.Liu XN, Naduvilath TJ, Wang J, Xiong S, He X, Xu X, et al. Sleeping late is a risk factor for myopia development amongst school-aged children in China. Sci Rep. 2020;10:17194.
10.Burkhart K, Phelps JR. Amber lenses to block blue light and improve sleep: a randomized trial. Chronobiol Int. 2009;26(8):1602-12.
11.Shechter A, Kim EW, St-Onge MP, Westwood AJ. Blocking nocturnal blue light for insomnia: a randomized controlled trial. J Psychiatr Res. 2018;96:196-202.
12.Esaki Y, Kitajima T, Ito Y, Koike S, Nakao Y, Tsuchiya A, et al. Wearing blue light-blocking glasses in the evening advances circadian rhythms in the patients with delayed sleep phase disorder: an open-label trial. Chronobiol Int. 2016;33(8):1037-44.
13.Ostrin LA, Abbott KS, Queener HM. Attenuation of short wavelengths alters sleep and the ipRGC pupil response. Ophthalmic Physiol Opt. 2017;37(4):440-50.
14.van der Lely S, Frey S, Garbazza C, Wirz-Justice A, Jenni OG, Steiner R, et al. Blue blocker glasses as a countermeasure for alerting effects of evening light-emitting diode screen exposure in male teenagers. J Adolesc Health. 2015;56(1):113-9.
15.Luna-Rangel FA, Gonzalez-Bedolla B, Salazar-Ortega MJ, Torres-Mancilla XM, Martinez-Cadena S. Efficacy of blue-light blocking glasses on actigraphic sleep outcomes: a systematic review and meta-analysis of randomized controlled crossover trials. Front Neurol. 2025;16:1699303.
16.Maeda-Nishino N, Yoshimoto R, Ono T, Otsuka R, Sato N, Adachi K, et al. Partial blue light blocking glasses at night advanced sleep phase and reduced daytime irritability, disruptive behavior and improved morning mood, but did not alter salivary melatonin secretion in Japanese male schoolchildren. PLoS One. 2025.
17.Zhao HL, Jiang J, Yu J, Xu HM. Role of short-wavelength filtering lenses in delaying myopia progression and amelioration of asthenopia in juveniles. Int J Ophthalmol. 2017;10(8):1261-7.
18.Owens JA, Spirito A, McGuinn M. The Children's Sleep Habits Questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. Sleep. 2000;23(8):1043-51.
19.Markovich AN, Gendron MA, Corkum PV. Validating the Children's Sleep Habits Questionnaire against polysomnography and actigraphy in school-aged children. Front Psychiatry. 2015;5:188.
20.Meltzer LJ, Montgomery-Downs HE, Insana SP, Walsh CM. Use of actigraphy for assessment in pediatric sleep research. Sleep Med Rev. 2012;16(5):463-75.