

Review

Hyperopia in children – from emmetropisation to spectacle correction: A narrative review

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ABSTRACT

Hyperopia is a common refractive state in childhood and may represent a physiological, age-dependent stage of refractive development. However, refractive magnitude alone does not determine its clinical significance, which also depends on the child's age, associated ocular findings and functional context. This narrative review provides an overview of emmetropisation in childhood, with particular emphasis on the relationship between hyperopia, refractive development and spectacle correction. Longitudinal studies demonstrate substantial age-related changes in ocular biometry and refractive error, while baseline hyperopia may influence the subsequent refractive trajectory. Whether spectacle correction modifies emmetropisation remains uncertain. Available clinical studies differ considerably in age at treatment initiation, baseline refractive error, degree of correction and clinical phenotype, limiting direct comparisons between studies. Studies comparing spectacle correction with observation do not demonstrate a simple, universal effect of correction on emmetropisation. Current clinical guidelines also differ in their numerical thresholds for prescribing correction but consistently emphasise the importance of visual function and ocular alignment. Across the available recommendations, younger age, higher hyperopia, amblyopia risk, reduced visual acuity, anisometropia and manifest strabismus are important factors in determining whether spectacle correction is indicated. Clinical management should therefore be individualised rather than based on refractive magnitude alone. Accommodative esotropia represents an important clinical modifier requiring full hyperopic correction, whereas observation with periodic reassessment may be appropriate in selected children without significant visual dysfunction. Overall, management should balance the potential for refractive development against the risks of amblyopia, strabismus and impaired visual function.

KEYWORDS

hyperopia, emmetropisation, refractive development, spectacle correction, children

Introduction

Most infants are hyperopic, and despite wide interindividual variation, hyperopia in early childhood is commonly considered physiological. However, the magnitude of initial hyperopia matters. Subsequent refractive development may follow different trajectories towards emmetropia, persistent hyperopia, or myopia [1,2]. Emmetropisation is a complex developmental process involving coordinated changes in axial length and the optical power of the cornea and crystalline lens. Although the mechanisms governing this process have been extensively studied, they remain incompletely understood.

The decision whether and when to correct hyperopia is clinically important. In some children, uncorrected hyperopia is associated with amblyopia and strabismus, particularly accommodative esotropia, and may adversely affect stereopsis and visual function [3,4]. At the same time, this decision can be challenging. Reliable assessment of refractive error in infants and young children is not always straightforward, and adequate cycloplegia may sometimes be difficult to achieve, potentially leading to underestimation of hyperopia [5]. Moreover, unnecessary correction should be avoided, while evidence remains inconclusive as to whether spectacle correction alters the natural course of emmetropisation [6,7].

The aim of this review is to provide a concise overview of emmetropisation and the potential influence of spectacle correction on refractive development in children with hyperopia. We also compare current recommendations for hyperopia correction and propose a practical approach to this common clinical decision.

Emmetropisation and refractive development in childhood

Most infants are hyperopic at birth, although longitudinal data demonstrate wide interindividual variation in refractive error. In a longitudinal cohort of 100 newborns examined within 24 hours of birth, 80% of eyes had hyperopia $>+2.00$ D and 25% $>+4.00$ D, with the proportion of eyes exceeding these levels of hyperopia decreasing substantially during the first year of life [8]. As the eye grows, axial elongation is accompanied by changes in its optical components, particularly flattening of the cornea and crystalline lens. Axial elongation produces a myopic shift, whereas decreasing corneal and lenticular power shifts refraction in the hyperopic direction [9]. The net refractive outcome therefore reflects the balance between these opposing changes (Figure 1) [2,9,10].

Refractive development may follow different trajectories towards emmetropia, persistent hyperopia or myopia. The pace of ocular development varies with age, with rapid axial elongation and substantial reductions in corneal and crystalline lens power during infancy, followed by slower changes that continue throughout childhood [9,11]. Baseline refractive status also appears to influence this trajectory. In a retrospective cohort of 375 infants (730 eyes), the monthly reduction in hyperopia increased with baseline hyperopia, from 0.00 D/month for $+0.25$ to $+1.50$ D to 0.11 D/month for $+3.50$ to $+5.75$ D. However, this relationship was not maintained in the highest hyperopia group ($\geq +6.00$ D), in which the monthly reduction was only 0.03 D/month [12]. Thus, the relationship between baseline hyperopia and subsequent emmetropisation may be non-linear, with very high hyperopia showing less refractive change than moderate hyperopia.

These clinical patterns reflect an underlying process of visually guided ocular growth.

Emmetropisation is considered an active process in which retinal image quality and defocus

provide signals contributing to its regulation. However, the mechanisms underlying this feedback remain incompletely understood [13]. Importantly, refractive development may depend not only on the initial refractive state but also on interventions such as spectacle correction. Thus, baseline refractive magnitude may modify both the natural course of refractive development and the response to intervention.

Consequently, the concept of “physiological hyperopia” should not be interpreted as a single numerical range of refractive error. The clinical significance of hyperopia depends on the child's age and stage of visual development, as well as on the individual refractive trajectory [10,14].

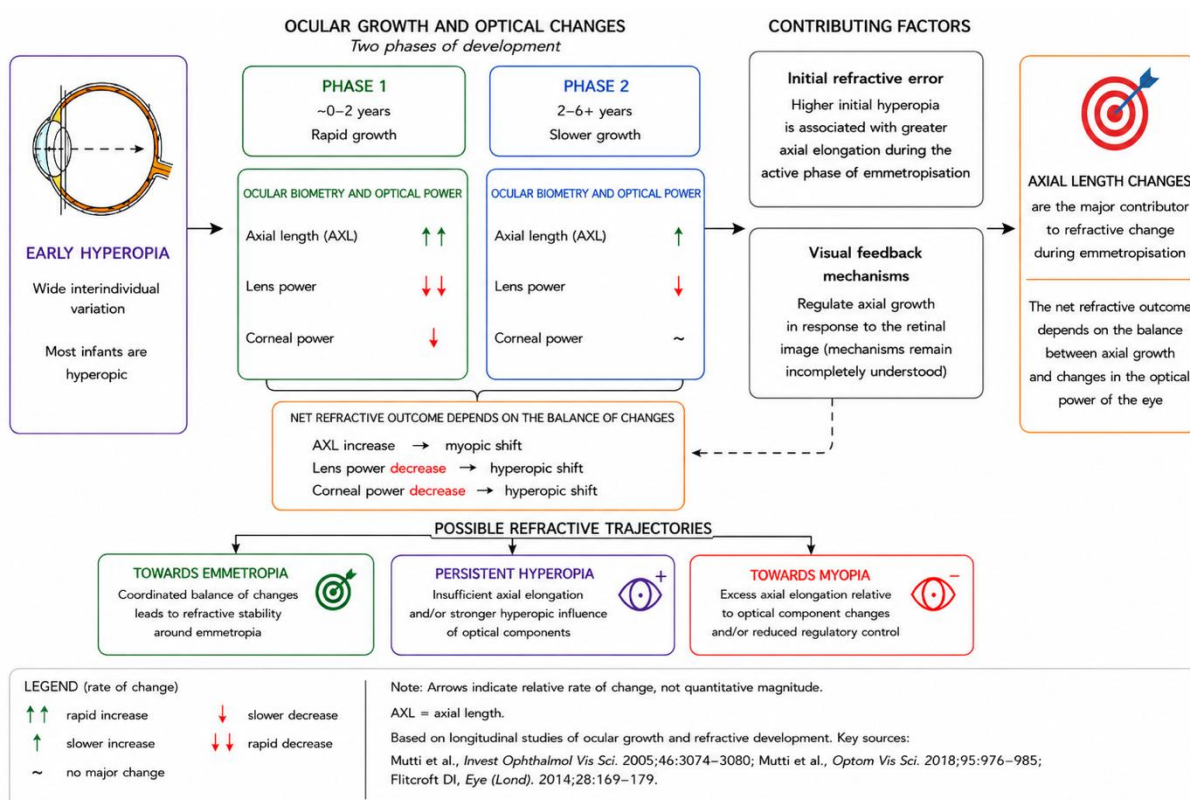


Fig. 1. Emmetropisation and refractive development during childhood: a simplified schematic representation

Spectacle correction and emmetropisation: current evidence

Whether spectacle correction may interfere with emmetropisation has been debated for several decades, reflecting a fundamental clinical dilemma: correction may improve visual function while simultaneously altering the visual signals that guide refractive development. Ingram et al. [15] were among the pioneers investigating whether spectacle correction could modify the natural course of emmetropisation in hyperopic infants. Atkinson et al. [7] subsequently addressed this question explicitly and conducted the first controlled longitudinal study designed specifically to investigate this issue.

Selected clinical studies investigating refractive development in hyperopic children and the

potential influence of spectacle correction on emmetropisation are summarised in Table I. These studies span a wide age range, from 3 months to 13 years, allowing the available evidence to be considered in the context of different stages of visual development.

Morrison et al. [16] published in 2025 the results of a clinical trial conducted in 35 3-month-old infants with high hyperopia ranging from +5.00 to +7.00 D. The intervention comprised partial correction (3.00 D less than cycloplegic hyperopia) and accommodative exercises, compared with observation. Follow-up continued to the age of 18 months. There was no difference in mean hyperopia between the groups at 18 months. However, the effect of treatment on emmetropisation differed according to baseline hyperopia: treatment slowed emmetropisation below +5.50 D but may have enhanced it above +5.50 D.

In 2000, Atkinson et al. [7] published the results of a trial involving 148 infants, including children with significant hyperopia ($\geq +3.50$ D) identified at 8–9 months of age and a separate non-hyperopic control group. Hyperopic infants received partial spectacle correction or were observed without correction until the age of 36 months. Hyperopia decreased in both groups, with no persistent difference between corrected and uncorrected infants at 36 months. The authors interpreted these findings as indicating that partial spectacle correction did not persistently interfere with emmetropisation.

Kulp et al. [17], on behalf of the Pediatric Eye Disease Investigator Group (PEDIG), reported in 2019 the results of a trial involving 130 children aged 12–35 months with hyperopia ranging from +3.00 to +6.00 D. Children received partial correction (1.00 D less than full cycloplegic correction) or observation. Spectacles were prescribed if deterioration occurred (pre-specified deterioration criteria of distance VA or near stereoacuity below age norms, or development of manifest strabismus). Little reduction in hyperopia was observed in either group, with no significant difference in emmetropisation between the groups.

Also in 2019, PEDIG investigators reported results in 119 children aged 3–5 years with hyperopia ranging from +3.00 to +6.00 D [18]. Children similarly received partial correction or observation, with correction prescribed if deterioration occurred. A greater reduction in hyperopia was observed in the observation group (~ 0.20 D/year), suggesting that a small effect of spectacle correction on emmetropisation could not be excluded.

Demirkilinc Biler et al. [19] reported in 2010 the results of a study involving 120 children aged 3–13 years with hyperopia $> +3.00$ D. In contrast to the aforementioned studies, these children had accommodative esotropia. The intervention consisted of full versus partial hyperopic correction, with partial correction adjusted to maintain ocular alignment and visual acuity. Allocation was not randomised but was based on tolerance of undercorrection. No difference in refractive

development was observed between the full- and partial-correction groups. The authors suggested that persistent hyperopia may reflect intrinsic refractive development rather than an effect of full spectacle correction.

Studies conducted at different stages of visual development therefore provide no consistent evidence that spectacle correction either uniformly inhibits or has no effect on emmetropisation. Differences in age at treatment initiation, baseline hyperopia, degree of correction and clinical phenotype substantially limit direct comparison between studies.

The difficulty in obtaining a conclusive answer may therefore reflect not only methodological limitations, but also the complexity of the question itself. Rather than asking whether spectacle correction affects emmetropisation, the question may need to be framed more specifically: in which children, at what age, at what level of baseline refractive error, and with what degree of correction might such an effect occur? The evidence regarding the influence of refractive correction on refractive development differs between hyperopia and myopia. In childhood myopia, interventions aimed at slowing refractive progression and axial elongation are supported by substantial evidence and clearer clinical recommendations, with management strategies selected according to individual clinical characteristics [20]. Although myopia control is beyond the scope of this review, this comparison illustrates that the relationship between refractive correction and subsequent refractive development may differ between hyperopia and myopia.

Table I. Selected clinical studies addressing spectacle correction and emmetropisation in childhood hyperopia

Study	Age at baseline	Baseline hyperopia	Population	Intervention	Follow-up duration	Refractive outcome	Clinical interpretation	Major limitation
Morrison et al. [16]	3 months	+5.00 to +7.00 D	35 infants with high hyperopia	Partial correction (3.00 D less than cycloplegic hyperopia) + accommodative exercises vs observation	To age 18 months	No difference in mean hyperopia at 18 months. Treatment slowed emmetropisation below +5.50 D but may have enhanced it above +5.50 D.	Baseline hyperopia may influence both the natural course of emmetropisation and the response to treatment.	Small sample (n=35); combined intervention (spectacles + accommodative exercises), limiting assessment of spectacle correction alone.
Atkinson et al. [7]	~8–9 months	≥+3.50 D	125 hyperopic infants; separate non-hyperopic control group	Partial spectacle correction vs observation without spectacles	To age 36 months	Hyperopia decreased in both groups; no difference between corrected and uncorrected infants at 36 months.	No persistent effect of partial correction on emmetropisation.	Substantial attrition; sample size varied across follow-up analyses.
Kulp et al./PEDIG [17]	12–35 months	+3.00 to +6.00 D	130 children with moderate hyperopia; no manifest strabismus	Partial correction (1.00 D less than full cycloplegic correction) vs observation; spectacles if deterioration occurred	3 years	Little reduction in hyperopia in either group; no difference between groups.	No clear advantage of spectacle correction over observation.	Planned sample size not reached.
Holmes et al./PEDIG [18]	3–5 years	+3.00 to +6.00 D	119 children with moderate hyperopia, age-appropriate VA and stereoacuity; no manifest strabismus	Partial correction (1.00 D less than full cycloplegic correction) vs observation; spectacles if deterioration occurred	3 years	Greater reduction in hyperopia with observation (~0.20 D/year).	A small effect of spectacle correction on emmetropisation cannot be excluded.	Emmetropisation was a planned secondary outcome.
Demirkiliç Biler et al. [19]	3–13 years; mean 7.66 ± 2.4 (partial), 7.84 ± 3.1 (full)	>+3.00 D	120 children with accommodative esotropia; 50 partial, 70 full correction	Full vs partial correction; allocation based on tolerance; partial correction adjusted to maintain alignment and VA	Mean 4.54 years (partial); 4.63 years (full)	No difference in refractive development between full and partial correction.	Persistent hyperopia may reflect intrinsic refractive development rather than an effect of full correction.	Non-randomized allocation based on tolerance; possible differences in accommodation between groups; wide age range (3–13 years), including older children less likely to show treatment-related effects on emmetropisation.

PEDIG – Pediatric Eye Disease Investigator Group; D – dioptres; VA – visual acuity

Hyperopia correction in children: current clinical guidelines

Clinical guidelines for the management of childhood hyperopia differ in several aspects. Table II summarises selected recommendations from the 2021 guidelines of the Polish Ophthalmological Society (PTO) [21,22], the 2023 guidelines of the American Academy of Ophthalmology (AAO) [23], and the 2012 guidelines of the Royal College of Ophthalmologists (RCOphth) [24].

The AAO provides age-specific numerical thresholds for spectacle correction, distinguishing between hyperopia with and without esotropia. The other guidelines do not provide comparable age-specific prescribing thresholds. The PTO identifies hyperopia $>+3.50$ D after 2 years of age as an amblyogenic risk factor rather than a prescribing threshold, whereas the RCOphth states that hyperopia up to $+4.00$ D may not require correction in the absence of strabismus, provided that visual acuity and binocular function are age-appropriate and no significant anisometropia or astigmatism is present.

Despite these differences, the recommendations share several important principles. Cycloplegic refraction and periodic reassessment are recommended, and the guidelines are broadly consistent regarding the importance of esotropia in decisions about spectacle correction. In accommodative esotropia, full cycloplegic hyperopic correction is recommended, whereas in children with exotropia the degree of hyperopic correction should be individualised according to the clinical findings and ocular alignment.

Thus, different approaches to numerical refractive thresholds ultimately address similar clinical questions: when should hyperopia be corrected, and when is observation appropriate?

Table II. Selected recommendations for spectacle correction of hyperopia in children

Guideline	Hyperopia without manifest strabismus	Hyperopia with esotropia	Additional clinical considerations
PTO, 2021	No general age-based prescribing thresholds. >+3.50 D after age 2 years: considered an amblyogenic risk factor	Full cycloplegic correction	Consider amblyopia and ocular alignment. In children with amblyopia without strabismus, up to 1.00 D undercorrection may be considered.
AAO, 2023	<1 y: $\geq +6.00$ D 1–<2 y: $\geq +5.00$ D 2–<3 y: $\geq +4.50$ D 3–<4 y: $\geq +3.50$ D	<1 y: $\geq +1.50$ D ≥ 1 y: $\geq +1.00$ D Accommodative esotropia: full cycloplegic correction	Consider clinical findings in all age groups. <4 y: consensus-based thresholds ≥ 4 y: no fixed thresholds; refractive error, VA and symptoms guide prescribing decisions
RCOphth, 2012	Up to +4.00 D: correction may not be required if there is no strabismus, VA and binocular function are age-appropriate, and no significant anisometropia or astigmatism is present. No age range specified.	$\geq +1.50$ D: correction recommended. Full hyperopic correction.	Cycloplegic refraction and periodic reassessment are recommended.

PTO – Polish Ophthalmological Society; AAO – American Academy of Ophthalmology; RCOphth – Royal College of Ophthalmologists; D – dioptre; VA – visual acuity

Sources: Polish Ophthalmological Society guidelines on amblyopia and childhood strabismus [21,22]; American Academy of Ophthalmology Pediatric Eye Evaluations Preferred Practice Pattern and guidance on esotropia [23]; Royal College of Ophthalmologists Guidelines for the Management of Strabismus in Childhood [24].

From cycloplegic refraction to spectacle prescription: a practical approach

Low hyperopia does not necessarily require correction, but its clinical significance cannot be determined from refractive magnitude alone. The same refractive error may have different clinical implications depending on the child's age and stage of visual development. For example, +3.00 D of hyperopia in a young child should be interpreted differently from the same refractive error persisting into school age, as both the magnitude and variability of hyperopia decrease with age [25]. Interpretation of cycloplegic refraction should therefore take into account expected age-related refractive development rather than relying on the measured number of dioptres in isolation (Figure 2).

The decision to prescribe spectacles should integrate refractive findings with the results of an age-appropriate ophthalmological assessment. Whenever possible, this should include visual acuity, ocular alignment, binocular function and cycloplegic refraction, together with assessment of the child's visual functioning. Additional assessment of accommodative function and binocular status may provide useful information when considering spectacle correction, including accommodative response and, where clinically relevant, phoria and the AC/A ratio. Ocular biometry, particularly serial axial length measurements, may also be useful for monitoring ocular growth and refractive development over time. The amount and reliability of information that can be obtained will inevitably vary with age, developmental stage and the child's ability to cooperate. Failure to obtain every component of a conventional examination, however, should not in itself preclude clinical decision-making [23].

Clinical findings should be considered together with the functional context. Visual symptoms and demands may be reported by the child and/or caregiver and may influence the significance attributed to a given refractive error. Particular attention should be paid to factors associated with impaired visual development, including amblyopia, anisometropia and astigmatism, as well as ocular alignment. The presence of hyperopic anisometropia may lower the threshold for spectacle correction, even when the absolute magnitude of hyperopia is low to moderate [22,23]. Esotropia is an especially important modifier: in accommodative esotropia, full cycloplegic hyperopic correction is generally required [23].

Depending on the child's age, refractive error, clinical findings and functional context, management may range from observation to partial or full spectacle correction (Figure 2).

Observation should not be interpreted as absence of management. In selected children, delaying necessary correction may contribute to persistent or increasing visual dysfunction and may adversely affect visual development [17]. Conversely, when immediate correction is not indicated,

periodic reassessment allows changes in refractive status and visual function to be detected over time.

Spectacle prescribing in childhood should therefore be regarded as a dynamic process rather than a single, irreversible decision. Refractive development, visual function and clinical circumstances may change as the child grows, requiring adjustment of the prescription during follow-up. Even when refraction remains stable, spectacles may need to be replaced or refitted as the child grows to ensure appropriate lens positioning and comfortable wear.

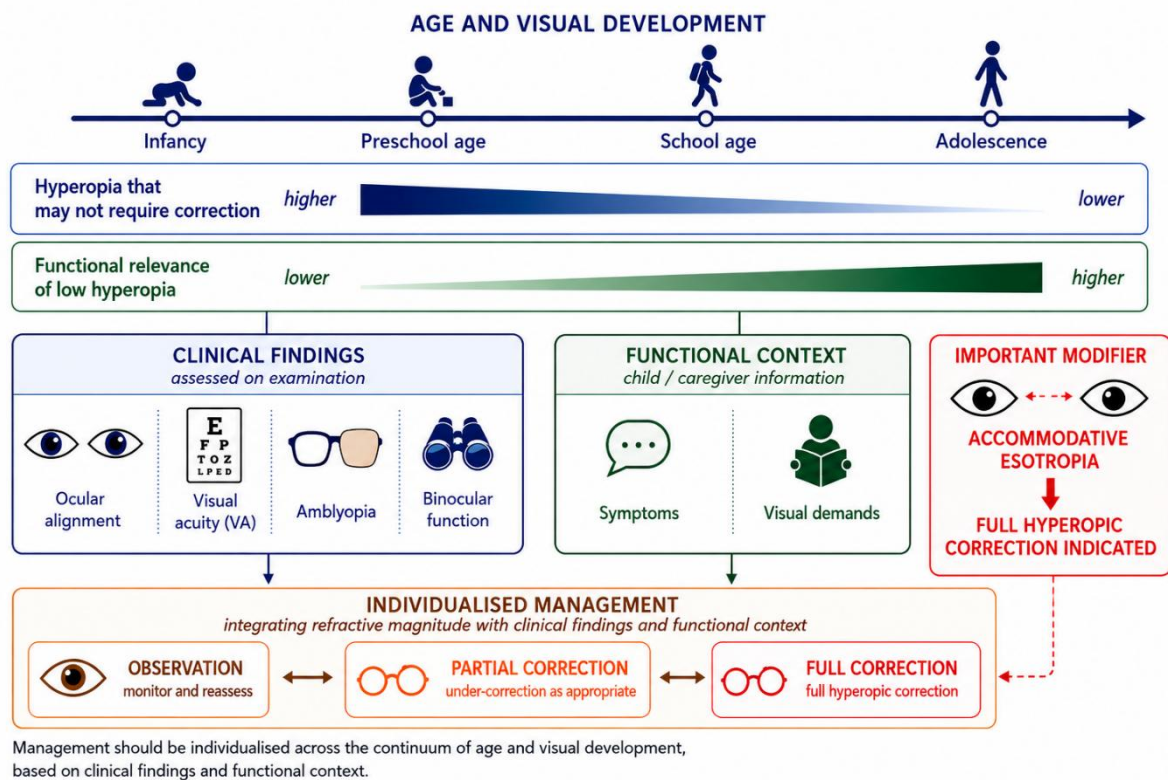


Fig. 2. Prescribing spectacle correction for childhood hyperopia: a practical approach

Conclusions

Hyperopia in childhood may represent a physiological, age-dependent stage of refractive development, but its clinical significance cannot be determined from refractive magnitude alone. Decisions regarding spectacle correction or observation should therefore integrate the magnitude of hyperopia with the child's age, clinical findings and functional context. The presence of esotropia is a particularly important clinical modifier; in accommodative esotropia, full hyperopic correction is generally indicated. Regular reassessment is essential, as refractive and visual development are dynamic processes and management may need to change over time. Available evidence does not demonstrate a simple, universal effect of spectacle correction on emmetropisation. Despite several decades of research, the relationship between spectacle correction and refractive development remains incompletely understood, particularly with regard

to the timing and degree of correction. Further studies should therefore focus on identifying which children are most likely to benefit from different correction strategies at different stages of visual development.

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