World Journal of Biology Pharmacy and Health Sciences
eISSN: 2582-5542
Cross Ref DOI: 10.30574/wjbphs
Journal homepage: https://wjbphs.com/

(REVIEW ARTICLE)

OCULOMOTOR FUNCTION AND SPECIFIC LEARNING DISABILITIES IN CHILDREN: A NARRATIVE REVIEW OF EVIDENCE, MECHANISMS AND CLINICAL IMPLICATIONS

Sk Saief Ali [1], Sarada Mukherjee [1], Mainak Motilal [1, 2, *] and Puja Sarbajna [1]

[1] Department of Optometry, Narayana Nethralaya, Bengaluru, Karnataka, India.
[2] Department of Optometry, GD Goenka University, Gurugram, Haryana, India.
* Corresponding Author

ORCID Details
Sk Saief Ali: https://orcid.org/0009-0000-5231-9695
Sarada Mukherjee: https://orcid.org/0009-0003-3818-5944
Mainak Motilal: https://orcid.org/0009-0006-8052-8295
Puja Sarbajna: https://orcid.org/0000-0002-5513-8475

World Journal of Biology Pharmacy and Health Sciences, 2026, 28(02), 024–033

Publication history: Received on 23 September 2026; revised on 30 October 2026; accepted on 02 November 2026

Article DOI: https://doi.org/10.30574/wjbphs.2026.28.2.0530

Copyright © 2026 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution License 4.0

ABSTRACT

Background: Specific learning disorders (SLDs), notably developmental dyslexia, affect a considerable proportion of children. Reading relies on correct saccades, steady binocular fixation, vergence, and accommodation. Whether oculomotor dysfunction causes, correlates with, or results from poor reading has been disputed for four decades.

Objective: To synthesize research on oculomotor dysfunction and learning difficulties, outline suggested causes, and rate the evidence for evaluation and intervention.

Methods: Narrative review utilizing PubMed/MEDLINE, Scopus and Google Scholar, with citation tracking, reported according to the SANRA criteria.

Results: Several controlled studies report more frequent saccadic, vergence, fixation and accommodative abnormalities in children with dyslexia than in typical readers, and a 2026 meta-analysis confirmed binocular and oculomotor differences, although certainty was low to very low. In one clinic-based cohort, 79% of children with dyslexia compared to 33% of normal readers showed at least one visual function deficiency. Evidence in attention-deficit/hyperactivity disorder (ADHD) and developmental coordination disorder is suggestive but less precise; evidence in dyscalculia and dysgraphia is poor. Causality is unresolved: magnocellular, cerebellar, and visual-attention explanations suggest key involvement, although aberrant eye movements also occur from decoding problems. In children with symptomatic convergence insufficiency, randomized data show that therapy improves binocular function but not reading skills.

Conclusions: Oculomotor: Dysfunction is a common, observable correlate of learning difficulties, but current data support neither a single causative role nor oculomotor therapy as a treatment for reading difficulty. Children with

learning difficulties should undergo a visual function evaluation to prevent overlooking curable binocular disorders, with evidence-based educational intervention.

Keywords: Oculomotor dysfunction; Vergence; Convergence insufficiency; Dyslexia; Specific learning disorder; Reading

1 INTRODUCTION

Specific learning disorder is a neurodevelopmental condition marked by chronic difficulties in acquiring reading, writing, expression, or mathematics abilities despite appropriate intellect, education, and opportunity [1]. Developmental dyslexia, the most studied variety, is highly heritable and is largely related to abnormalities in phonological processing, although multiple-deficit theories are also commonly recognized [2,3].

Skilled reading needs a specific sequence of visuomotor events: saccades of suitable magnitude move the eyes down a line, both eyes must then fixate in a stable and aligned way, and accommodation must maintain text visible at close distance [4]. Failure of any component might, in theory, impair the visual input to the reading network. This probable relationship has spawned a long-running dispute over whether 'faulty eye movements' cause reading difficulty or merely reflect it [5]. The dispute has practical weight since families may regularly be offered vision-based therapies for learning difficulties. A joint policy statement from pediatric and ophthalmic authorities stated that vision impairments are not a main cause of dyslexia and that eye exercises, behavioral vision therapy and colored glasses lack scientific backing as direct or indirect therapies for learning disorders [6]. At the same time, fresh controlled data reveal that visual function abnormalities are more prevalent in children with dyslexia than in typical readers [7], and a recent meta-analysis of case-control studies reached a similar result while grading the confidence of the evidence as low to very low [8].

This review consequently poses three questions: (i) Is oculomotor dysfunction related to learning disabilities? (ii) What processes might explain the link, and what is the direction of causality? (iii) What are the consequences for evaluation and management?

2 METHODS

2.1 Review design

This is a narrative review, designed according to the SANRA criteria for the quality assessment of narrative reviews (justification of significance, defined objectives, explanation of literature search, referencing, scientific reasoning and suitable presentation of data) [9].

2.2 Literature search

PubMed/MEDLINE, Scopus and Google Scholar were searched from inception to October 2026 using combinations of: oculomotor, eye movements, saccade, vergence, fixation, convergence insufficiency, accommodation, dyslexia, reading disability, learning disability, specific learning disorder, ADHD, developmental coordination disorder. Reference lists of major papers and consensus statements were hand-searched. Targeted searches were included for current systematic reviews and meta-analyses of visual and oculomotor function in dyslexia and ADHD and for follow-up reports of vergence and accommodative therapy studies.

2.3 Eligibility and synthesis

English-language human studies in children and adolescents that assessed oculomotor, binocular or accommodative function in individuals with learning difficulties versus controls, or that tested therapies targeting these skills, were prioritized. Case reports, studies of acquired reading difficulties, and studies without a specified learning-disability group were excluded. Study quality was appraised narratively, and results were synthesized thematically. No systematic meta-analysis or risk-of-bias score was done. As a narrative review, no ethical clearance was necessary.

3 OCULOMOTOR CONTROL IN READING: A BRIEF PHYSIOLOGICAL FRAMEWORK

During reading, fixations of approximately 200–250 ms are interrupted by saccades spanning approximately seven to nine letter spaces, with occasional regressions to prior material [4]. Both eyes must be coordinated: saccades are generally somewhat disconjugate and are followed by vergence adjustments that restore binocular alignment during fixation [10]. Three subsystems are thus relevant:

- Version (saccades, pursuit, fixation): accuracy, latency, inhibitory control, and gaze stability.
- Vergence: convergence and divergence, defined clinically by the near point of convergence (NPC) and fusional vergence amplitudes.
- Accommodation: focusing, strongly connected to convergence via the near triad.

Table 1 outlines these functions, the irregularities found in learning disorders, and the clinical tests used to identify them.

Table 1: Oculomotor subsystems relevant to reading, reported abnormalities in learning disabilities, and common clinical measures

Subsystem	Normal role in reading	Abnormality reported in learning disabilities	Common clinical/laboratory measures
Saccades	Move gaze along text; return sweep	Longer or more numerous fixations, more regressions, inaccurate or disconjugate saccades [11–18]	Developmental Eye Movement test, King-Devick test, video-oculography
Fixation and inhibitory control	Maintain stable gaze on word; suppress reflexive saccades	Unstable binocular fixation; more antisaccade errors [12,17,19]	Fixation stability, antisaccade task
Smooth pursuit	Tracking moving targets (limited role in reading)	Inconsistent findings; weaker evidence	Pursuit gain on eye tracker; clinical pursuit testing
Vergence	Keep both eyes aligned on near print	Reduced fusional amplitudes, convergence insufficiency and post-saccadic disconjugacy reported in some studies [7,13,14,20]	NPC, prism fusional vergence, cover test
Accommodation	Keep print in focus	Reduced amplitude of accommodation and/or accommodative facility [7,21]	Amplitude of accommodation, flipper facility

Note: Clinical measures are listed for orientation. Impaired performance on rapid-naming-based tests such as the Developmental Eye Movement (DEM) test or King-Devick test may reflect language and automaticity rather than purely oculomotor deficits, and should be interpreted with caution.

4 EVIDENCE FOR AN ASSOCIATION WITH LEARNING DISABILITIES

4.1 Developmental dyslexia

Most of the available evidence concerns developmental dyslexia. In an early controlled investigation, Eden and colleagues showed impaired binocular fixation and vergence control in children with dyslexia, even in tasks that did not require reading, whereas poor readers without dyslexia did not show these abnormalities [11]. Biscaldi and colleagues showed decreased voluntary saccadic control, including higher error rates on tasks that required inhibition of reflexive saccades [12], and Fischer and Hartnegg later documented how such deficiencies evolved with development and responded to training [22].

Binocular recording studies have further supported this pattern. Bucci and colleagues revealed that children with dyslexia (n = 18) have lower binocular coordination during and after saccades than age-matched controls (n = 13), independent of task [13]. Jainta and Kapoula found unstable binocular focus during actual text reading [19]. A subsequent study compared children with dyslexia with both chronological-age-matched and reading-age-matched controls and found that the group with dyslexia resembled younger, reading-age-matched children, with more and longer fixations and poorer binocular coordination in both reading and visual search, which the authors interpreted as immaturity of saccade–vergence interaction [14]. A subsequent developmental study also revealed reduced binocular saccade coordination during visual search, a non-reading activity [15].

Clinical cohort data corroborate this tendency. In a prospective, non-randomized, clinic-based comparison of 29 children with dyslexia and 33 typical readers, accommodation deficits were found in 55% versus 9%, impaired oculomotor tracking in 62% versus 15%, and vergence deficits in 34% versus 15% (not statistically significant); overall, 79% of children with dyslexia had at least one visual function deficit compared with 33% of controls [7]; these findings establish an association but do not demonstrate a reading-specific mechanism. Other studies of children with reading

problems reveal a larger incidence of binocular defects and relationships between oculomotor function and reading speed [20,21]. Antisaccade and predictive-saccade anomalies have also been identified [17].

Evidence syntheses are now accessible. A 2026 systematic review and meta-analysis of 26 case-control studies found that individuals with dyslexia had greater near exophoria, reduced near fusional vergence ranges, more and longer fixations, more regressions, reduced saccade amplitude, and greater saccadic disconjugacy than controls, whereas refractive error and visual acuity did not differ, and near point of convergence and stereopsis did not differ in the primary pooled analysis [8]. The authors assessed the confidence of the evidence as low to very low because of heterogeneity, risk of bias, and imprecision, and all included trials were non-randomized [8]. Findings are not consistent across methods: a previous meta-analysis confined to nystagmography recordings found longer fixation periods but fewer, rather than more, saccades in children with dyslexia [23]. Recent clinic-based investigations also reveal binocular and visual function abnormalities in children with dyslexia [24,25].

Several important counterfindings exist. In German-speaking youngsters reading a regular orthography, atypical eye movements, such as greater fixations and regressions, were attributed to the reading difficulty itself [16]. Prado and colleagues observed that group differences in eye movements during visual search were linked to visual attention span rather than to a pure oculomotor deficiency [26]. Ward and Kapoula found that regressions and saccade disconjugacy in teenagers with dyslexia increased with text difficulty and that regressions were predominantly a sign of decoding difficulties [18]. Study features and limitations are presented in Table 2.

Table 2: Selected studies on oculomotor/visual function in learning disabilities

First author, year	Population	Design/method	Principal finding	Main limitations
Eden, 1994 [11]	26 children with dyslexia, 39 typical readers (plus backward readers)	Eye-movement recording in non-reading tasks (fixation, vergence, saccades, pursuit)	Abnormal binocular fixation and vergence control outside reading; poor readers without dyslexia performed similarly	Small samples; older recording methods; deficits not specific to dyslexia
Biscaldi, 2000 [12]	Children with dyslexia and controls	Saccadic tasks, including antisaccade	Impaired voluntary saccadic control; more errors when reflexive saccades must be suppressed	Cross-sectional; cause and effect cannot be separated
Fischer, 2008 [22]	Children with dyslexia	Saccade-control assessment across development, with training	Developmental change in saccade control; improvement with training; transfer to reading reported	Uncontrolled or quasi-experimental evidence; not an RCT
Hutzler, 2004 [16]	Children with dyslexia, regular orthography	Eye movements during reading	Anomalies interpreted as effects of reading difficulty	Orthography-specific
Prado, 2007 [26]	Children with dyslexia and controls	Reading and visual search	Differences linked to visual attention span	Attentional confound
Bucci, 2008 [13]	18 children with dyslexia, 13 age-matched controls	Binocular saccade recording, word reading and LED fixation	Poorer binocular coordination and larger post-saccadic drift	Small sample; cross-sectional
Palomo-Álvarez, 2010 [20]	School children with reading difficulties and controls	Clinical tests of binocular function	Greater burden of binocular anomalies in children with reading difficulties	Reading difficulty not necessarily equivalent to dyslexia; cross-sectional
Jainta, 2011 [19]	Children with and without dyslexia	Binocular tracking during text reading	Unstable binocular fixation during reading	Cannot separate cause from effect

Bucci, 2012 [14]	12 children with dyslexia; 9 age-matched and 10 reading-age-matched controls	Reading and visual search tasks	Pattern in dyslexia resembled younger, reading-age controls	Very small groups
Quaid, 2013 [21]	Children with reading disability and controls	Cycloplegic refraction, oculomotor and vergence tests, reading speed	Reduced vergence facility in the reading-disabled group; reading speed correlated with refractive error and vergence facility	Cross-sectional; association only
Seassau, 2014 [15]	Typical readers and children with dyslexia	Binocular saccade coordination in reading and visual search (developmental design)	Altered binocular saccade coordination in visual search, a non-reading task	Cross-sectional; cause and effect cannot be separated
Lukasova, 2016 [17]	Children with dyslexia and controls	Antisaccade and predictive-saccade tasks	Antisaccade and predictive-saccade abnormalities	Cross-sectional; association only
Raghuram, 2018 [7]	29 children with developmental dyslexia, 33 typical readers (~10 y)	Prospective clinical comparison of vergence, accommodation and tracking	Higher frequency of deficits in dyslexia (79% vs 33%)	Nonrandomized, clinic-based, single centre; no causal inference or reading-specific mechanism
CITT-ART, 2019 [27]	310 children aged 9–14 y with symptomatic CI	Randomized (2:1), double-masked, office-based placebo therapy, 16 weeks	Vergence/accommodative therapy was not superior to placebo therapy for reading outcomes	Selected for CI, not for dyslexia; generalisability to dyslexia limited
Ward, 2021 [18]	Adolescents with dyslexia and controls	Binocular tracking, simple vs difficult text	Disconjugacy and regressions worsened with text difficulty	Modest sample; adolescents only
Martínez-Pérez, 2026 [8]	26 case-control studies (8 to 124 participants per group)	Systematic review and meta-analysis (PROSPERO-registered; MINORS, GRADE)	More near exophoria, reduced fusional vergence, more and longer fixations and more regressions; no difference in refractive error or acuity	Certainty low to very low; high heterogeneity; non-randomized studies

Rows are ordered chronologically. Selection criteria: primary studies and syntheses in dyslexia discussed in Section 4.1, plus the CITT-ART randomized trial discussed in Section 6.2. Evidence for ADHD and developmental coordination disorder is summarized in Table 3, and intervention evidence is presented in Table 4. CI, convergence insufficiency.

4.2 Other learning and neurodevelopmental conditions

Evidence outside dyslexia is more limited. In children with ADHD, which commonly co-occurs with SLD, saccadic latency is more variable, antisaccade direction errors are more frequent, and fixation is less stable [28,29]. A meta-analysis of 31 studies indicated a modest pooled effect for antisaccade direction mistakes, with considerable between-study variability [30], but a systematic review confined to children tested off medication rated the data inadequate for solid conclusions [31]. These anomalies reflect inhibitory and attentional control rather than a reading-specific mechanism, and since ADHD and dyslexia commonly co-occur, comorbid reading difficulties are a substantial potential confound unless it is expressly avoided. In developmental coordination disorder, which typically accompanies dyslexia and dysgraphia, issues in eye–hand coupling have been documented [32]. We identified no convincing controlled studies of oculomotor abnormalities in dyscalculia or dysgraphia alone. This probably reflects the fact that these conditions are less often studied with oculomotor outcomes: research on dyscalculia has focused largely on number-processing and visuospatial paradigms, and research on dysgraphia on handwriting and fine-motor measures, which use different methods from eye-movement or binocular testing. These situations are consequently classified as evidence gaps (Table 3).

Table 3: Strength of evidence linking oculomotor dysfunction to specific conditions

Condition	Oculomotor/visual findings	Consistency	Evidence strength
Developmental dyslexia	Saccadic, fixation, vergence, accommodative and tracking abnormalities	Direction generally consistent in binocular and clinical studies and in a recent meta-analysis [8], but heterogeneous, with some negative or confounded findings	Low to moderate for association; low for causation
ADHD (often comorbid with SLD)	Inhibitory saccade errors, variable latency, fixation instability [28–31]	Direction generally consistent but heterogeneous and nonspecific; comorbid dyslexia is a major confound	Low to moderate (association)
Developmental coordination disorder	Eye–hand coordination deficits [32]	Limited	Low
Dyscalculia, dysgraphia (isolated)	Few or no controlled studies identified	Not assessable	Insufficient

Evidence-strength terms are qualitative. Moderate: several controlled studies from different laboratories or clinics point in the same direction, with some heterogeneity or confounding, but no longitudinal or experimental data permit causal inference. Low: few, small, or indirect studies, or evidence from a single line of work. Insufficient: no controlled data identified.

5 PROPOSED MECHANISMS AND THE QUESTION OF CAUSALITY

Four non-exclusive accounts have been advanced. Magnocellular/dorsal-stream theory. Impaired magnocellular processing is postulated to impair motion and timing signals, creating unstable fixation, poor binocular control and visual crowding [33,34]. Although influential, this hypothesis does not explain phonological deficiencies in all people and remains controversial.

Cerebellar hypothesis. Cerebellar impairment might affect automatization of reading as well as saccade calibration and vergence learning [35]. This hypothesis is consistent with interpretations of binocular saccade data as indicating immature oculomotor learning [13,14], although these studies do not explicitly test cerebellar function.

Visual-attention theory. Deficits in visuospatial attention may underlie both aberrant scan pathways and poor orthographic processing [36]. Preliminary data demonstrate that attentional abilities in prereaders predict subsequent reading acquisition [37], and outcomes in visual search tasks are aligned with this approach [26].

Consequence theory. Reading is a skill that teaches oculomotor conduct. Children who decode inefficiently will naturally make more and longer fixations and more regressions, especially with difficult material [5,16,18]. The likeness of children with dyslexia to younger, reading-age-matched controls [14] is congruent with both a developmental-immaturity and a reading-experience explanation.

At present, the results best support a bidirectional, heterogeneous model: in a subset of children, primary oculomotor or binocular dysfunction may lead to reading problems; in others, eye movement abnormalities are secondary; and in many, both processes interact (Figure 1). Prospective longitudinal studies in prereaders, with oculomotor testing before reading instruction, are needed to clarify causality.

6 IMPLICATIONS FOR ASSESSMENT AND MANAGEMENT

6.1 Assessment

Because treatable binocular anomalies such as convergence insufficiency are common and can cause asthenopia, loss of place and reduced near-work stamina, children with learning difficulties should undergo a comprehensive visual examination including refraction, cover test, NPC, fusional vergence and accommodation [6,7]; diagnostic approaches to oculomotor anomalies in children with learning disorders have been reviewed elsewhere [38]. Oculomotor screening must not postpone or replace psychoeducational examination. A possible approach is presented in Figure 1.

6.2 Treatment evidence

The Convergence Insufficiency Treatment Trial demonstrated that office-based vergence/accommodative therapy was the most effective treatment for symptomatic convergence insufficiency in children [39]. The follow-up CITT-ART trial randomized children aged 9–14 years with symptomatic convergence insufficiency, in a 2:1 ratio, to 16 weeks of office-based vergence/accommodative therapy or office-based placebo therapy (the reading-outcome report [27] describes 310 randomized children, whereas the companion treatment report [40] describes 311; 310 is used here). Therapy increased near point of convergence and positive fusional vergence [40], with gains remaining at one year in those followed up [41], although it was no more effective than placebo therapy for increasing standardized reading performance in these children [27]. Small or methodologically limited studies have reported possible benefits of saccade training (uncontrolled or quasi-experimental evidence) [22] and of orthoptic treatment compared with reading tutoring [42], but these findings have not been confirmed in large randomized trials, and a critical appraisal concluded that evidence supporting behavioral vision therapy is weak outside convergence insufficiency [6]. The orthoptic trial [42] is an older study of 62 children; its age, small sample size, and limited reporting by current standards suggest a substantial risk of bias.

Table 4: Intervention evidence relevant to learning disabilities

Intervention	Effect on binocular/oculomotor function	Effect on reading/learning outcome	Evidence quality	Practical recommendation
Office-based vergence/accommodative therapy (convergence insufficiency)	Improves NPC and fusional vergence [40,41]	No benefit over placebo [27]	High (single RCT; population selected for symptomatic CI)	Treat for visual symptoms, not to improve reading
Saccade/oculomotor training	Improved saccade control reported [22]	Transfer to reading reported in uncontrolled or quasi-experimental studies; not confirmed in large RCTs	Low	Experimental; research use
Orthoptic treatment vs reading tutoring	Not the main focus	Older comparative trial (n = 62), likely high risk of bias [42]	Low	Insufficient to recommend
Spectacle correction of refractive error/accommodative problems	Improves visual clarity and comfort	Indirect benefit; improves visual clarity and comfort but does not treat dyslexia directly	Moderate, based on general clinical evidence rather than dyslexia-specific RCTs	Correct clinically significant errors
Evidence-based reading instruction	Not applicable	Established benefit for reading outcomes [2,3]	High	First-line for all children with SLD

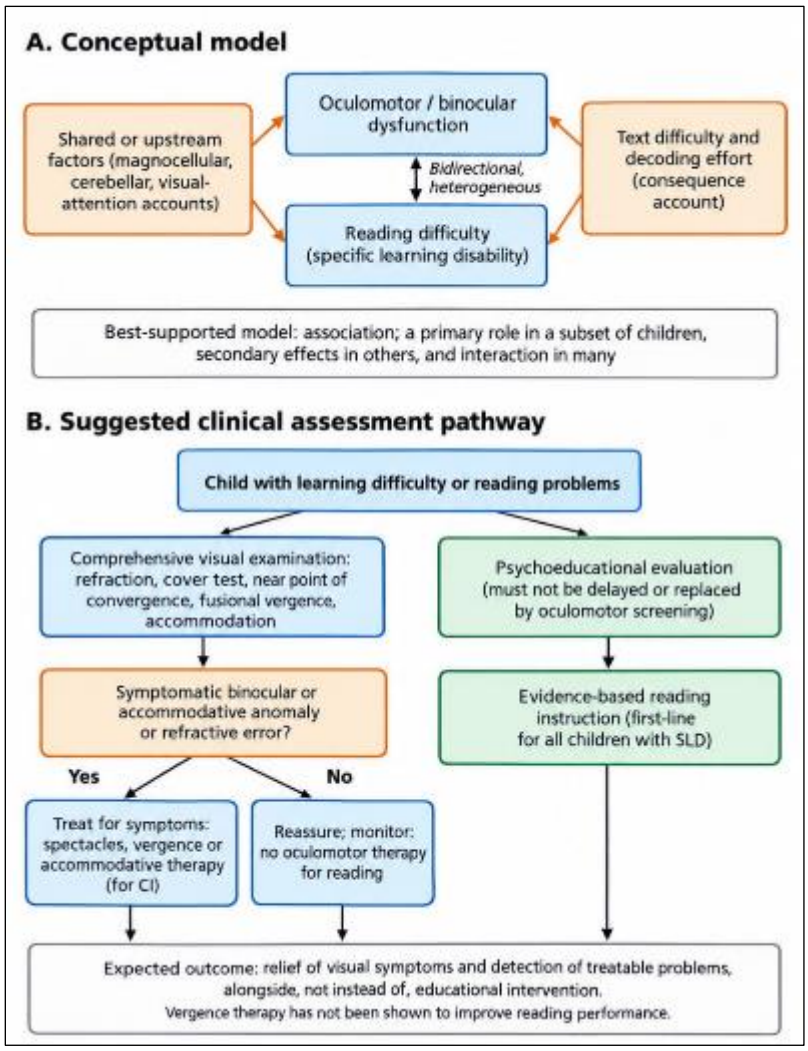


Figure 1: Conceptual model of relationship between oculomotor dysfunction and learning disabilities (A) and a suggested clinical assessment pathway (B).

7 STRENGTHS AND LIMITATIONS OF THE EVIDENCE BASE AND OF THIS REVIEW

Many studies use small samples, different definitions of dyslexia, various orthographies, varied recording techniques and cross-sectional designs, which limit conclusions regarding causality. Selection bias (clinic-based samples) and publication bias are possible, and even the most recent meta-analysis assessed the confidence of evidence for most visual and oculomotor outcomes as low or very low [8]. This review was narrative rather than systematic, with no rigorous risk-of-bias evaluation, and important studies may have been overlooked. Conclusions regarding ADHD, DCD, dyscalculia, and dysgraphia remain uncertain.

7.1 Future directions

(1) Longitudinal studies of prereaders testing whether oculomotor measures predict later reading; (2) larger, preregistered studies with matched reading-age and chronological-age controls and cross-orthography comparison; (3) randomized trials targeting children with both dyslexia and a documented oculomotor deficit, with blinded reading outcomes; (4) standardized, validated screening tools that separate oculomotor from language-based performance; (5) studies in under-researched conditions such as dyscalculia and dysgraphia, and in low- and middle-income settings.

8 CONCLUSION

Oculomotor and binocular dysfunction are more prevalent in children with dyslexia than in typical readers, and in some children they may lead to visual symptoms and reading discomfort. The data do not support oculomotor dysfunction as the source of learning impairment, and, in children with symptomatic convergence insufficiency, effective treatment of the binocular issue has not been proven to enhance reading results. Clinical management should combine a visual examination to diagnose and treat symptomatic visual issues with prompt, evidence-based educational assistance.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

The authors report no conflicts of interest.

REFERENCES

[1] American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 5th ed., text revision (DSM-5-TR). Washington (DC): American Psychiatric Association Publishing; 2022.

[2] Peterson RL, Pennington BF. Developmental dyslexia. The lancet. 2012 May 26;379(9830):1997-2007.

[3] Shaywitz SE. Dyslexia. N Engl J Med. 1998 Jan 29;338(5):307-12. doi: 10.1056/NEJM199801293380507. PMID: 9445412.

[4] Rayner K. Eye movements in reading and information processing: 20 years of research. Psychological bulletin. 1998 Nov;124(3):372.

[5] Rayner K. Do faulty eye movements cause dyslexia?. Developmental Neuropsychology. 1985 Jan 1;1(1):3-15.

[6] Handler SM, Fierson WM, Section on Ophthalmology and Council on Children with Disabilities, American Academy of Ophthalmology, American Association for Pediatric Ophthalmology and Strabismus, and American Association of Certified Orthoptists. Learning disabilities, dyslexia, and vision. Pediatrics. 2011 Mar 1;127(3):e818-56.

[7] Raghuram A, Gowrisankaran S, Swanson E, Zurakowski D, Hunter DG, Waber DP. Frequency of visual deficits in children with developmental dyslexia. JAMA ophthalmology. 2018 Oct;136(10):1089-95.

[8] Martinez-Perez C, Oliveira AP, Baltazar I. Visual and Oculomotor Function in Developmental Dyslexia: A Systematic Review and Meta-Analysis. Ophthalmic and Physiological Optics. 2026 May;46(2):152-69.

[9] Baethge C, Goldbeck-Wood S, Mertens S. SANRA—a scale for the quality assessment of narrative review articles. Research integrity and peer review. 2019 Mar 26;4(1):5.

[10] Kirkby JA, Webster LA, Blythe HI, Liversedge SP. Binocular coordination during reading and non-reading tasks. Psychological bulletin. 2008 Sep;134(5):742.

[11] Eden GF, Stein JF, Wood HM, Wood FB. Differences in eye movements and reading problems in dyslexic and normal children. Vision research. 1994 May 1;34(10):1345-58.

[12] Biscaldi M, Fischer B, Hartnegg K. Voluntary saccadic control in dyslexia. Perception. 2000;29(5):509-21.

[13] Bucci MP, Brémond-Gignac D, Kapoula Z. Poor binocular coordination of saccades in dyslexic children. Graefe's archive for clinical and experimental ophthalmology. 2008 Mar;246(3):417-28.

[14] Bucci MP, Nassibi N, Gerard CL, Bui-Quoc E, Seassau M. Immaturity of the oculomotor saccade and vergence interaction in dyslexic children: evidence from a reading and visual search study. PloS one. 2012 Mar 16;7(3):e33458.

[15] Seassau M, Gérard CL, Bui-Quoc E, Bucci MP. Binocular saccade coordination in reading and visual search: a developmental study in typical reader and dyslexic children. Frontiers in integrative neuroscience. 2014 Oct 30;8:85.

[16] Hutzler F, Wimmer H. Eye movements of dyslexic children when reading in a regular orthography. Brain and language. 2004 Apr 1;89(1):235-42.

[17] Lukasova K, Silva IP, Macedo EC. Impaired oculomotor behavior of children with developmental dyslexia in antisaccades and predictive saccades tasks. Frontiers in Psychology. 2016 Jun 30;7:987.

[18] Ward LM, Kapoula Z. Dyslexics' fragile oculomotor control is further destabilized by increased text difficulty. Brain Sciences. 2021 Jul 27;11(8):990.

[19] Jainta S, Kapoula Z. Dyslexic children are confronted with unstable binocular fixation while reading. PloS one. 2011 Apr 6;6(4):e18694.

[20] Palomo-Álvarez C, Puell MC. Binocular function in school children with reading difficulties. Graefe's archive for clinical and experimental ophthalmology. 2010 Jun;248(6):885-92.

[21] Quaid P, Simpson T. Association between reading speed, cycloplegic refractive error, and oculomotor function in reading disabled children versus controls. Graefe's archive for clinical and experimental ophthalmology. 2013 Jan;251(1):169-87.

[22] Fischer B, Hartnegg K. Saccade Control in Dyslexia: Development, Deficits, Training and Transfer to Reading. Optometry & Vision Development. 2008 Dec 1;39(4):181.

[23] Macambira YK, Barbosa JV, Queiroga BM, Cordeiro AA, Menezes DC, Lima ML, Advíncula KP. Ocular findings from otoneurological examinations in children with and without dyslexia: a systematic review with meta-analysis. Brazilian Journal of Otorhinolaryngology. 2022 Nov 25;88(Suppl 3):192-201.

[24] Mukhtar IS, Ezinne NE, Mohamad Shahimin M, Mohd-Ali B, Oghre E, Zeried FM, Osuagwu UL. Age-matched comparative analysis of binocular vision anomalies among children with dyslexia in northern Nigeria. Pediatric Reports. 2024 Jul 15;16(3):566-78.

[25] Darvishi A, Sangsefidi N, Shandiz JH, Rad DS, Narooie-Noori F, Khorrami-Nejad M. Visual function deficits in dyslexic children: a case-control study. BMC ophthalmology. 2025 Mar 18;25(1):144.

[26] Prado C, Dubois M, Valdois S. The eye movements of dyslexic children during reading and visual search: impact of the visual attention span. Vision research. 2007 Sep 1;47(19):2521-30.

[27] CITT‐ART Investigator Group. Effect of vergence/accommodative therapy on reading in children with convergence insufficiency: a randomized clinical trial. Optometry and vision science. 2019 Nov;96(11):836-49.

[28] Munoz DP, Armstrong IT, Hampton KA, Moore KD. Altered control of visual fixation and saccadic eye movements in attention-deficit hyperactivity disorder. Journal of neurophysiology. 2003 Jul;90(1):503-14.

[29] Rommelse NN, Van der Stigchel S, Sergeant JA. A review on eye movement studies in childhood and adolescent psychiatry. Brain Cogn. 2008 Dec;68(3):391-414. doi: 10.1016/j.bandc.2008.08.025. Epub 2008 Oct 2. PMID: 18835079.

[30] Chamorro Y, Betz LT, Philipsen A, Kambeitz J, Ettinger U. The eyes have it: A meta-analysis of oculomotor inhibition in attention-deficit/hyperactivity disorder. Biological Psychiatry: Cognitive Neuroscience and Neuroimaging. 2022 Nov 1;7(11):1090-102.

[31] Sherigar SS, Gamsa AH, Srinivasan K. Oculomotor deficits in attention deficit hyperactivity disorder: a systematic review and meta-analysis. Eye. 2023 Jul;37(10):1975-81.

[32] Wilmut K, Wann JP, Brown JH. Problems in the coupling of eye and hand in the sequential movements of children with developmental coordination disorder. Child: care, health and development. 2006 Nov;32(6):665-78.

[33] Stein J, Walsh V. To see but not to read; the magnocellular theory of dyslexia. Trends in neurosciences. 1997 May 1;20(4):147-52.

[34] Stein J. The magnocellular theory of developmental dyslexia. Dyslexia. 2001 Jan;7(1):12-36.

[35] Nicolson RI, Fawcett AJ, Dean P. Developmental dyslexia: the cerebellar deficit hypothesis. Trends in neurosciences. 2001 Sep 1;24(9):508-11.

[36] Vidyasagar TR, Pammer K. Dyslexia: a deficit in visuo-spatial attention, not in phonological processing. Trends in cognitive sciences. 2010 Feb 1;14(2):57-63.

[37] Franceschini S, Gori S, Ruffino M, Pedrolli K, Facoetti A. A causal link between visual spatial attention and reading acquisition. Current biology. 2012 May 8;22(9):814-9.

[38] Bilbao C, Piñero DP. Diagnosis of oculomotor anomalies in children with learning disorders. Clin Exp Optom. 2020;103:597-609. doi:10.1111/cxo.13024

[39] Convergence Insufficiency Treatment Trial Study Group. Randomized clinical trial of treatments for symptomatic convergence insufficiency in children. Archives of ophthalmology. 2008 Oct 13;126(10):1336-49.

[40] CITT-ART Investigator Group. Treatment of Symptomatic Convergence Insufficiency in Children Enrolled in the Convergence Insufficiency Treatment Trial-Attention & Reading Trial: A Randomized Clinical Trial. Optom Vis Sci. 2019 Nov;96(11):825-835. doi: 10.1097/OPX.0000000000001443. PMID: 31651593; PMCID: PMC6855327.

[41] Morrison AM, Kulp MT, Cotter SA, Scheiman MM, Jenewein EC, Roberts TL, Mitchell GL, Arnold LE, Retnasothi D, Bade A, Hertle R, Borsting E; Convergence Insufficiency Treatment Trial—Attention and Reading (CITT‐ART) Investigator Group. One-year follow-up of clinical convergence measures in children enrolled in the Convergence Insufficiency Treatment Trial-Attention and Reading Trial. Ophthalmic Physiol Opt. 2024 Nov;44(7):1346-1353. doi: 10.1111/opo.13378. Epub 2024 Aug 14. PMID: 39141379; PMCID: PMC12134983.

[42] Atzmon D, Nemet P, Ishay A, Karni E. A randomized prospective masked and matched comparative study of orthoptic treatment versus conventional reading tutoring treatment for reading disabilities in 62 children. Bin Vis Eye Muscle Surg Q. 1993;8(2):91-106.