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Effect of visual search training on quality of life and visual performance: a systematic review

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ABSTRACT

Homonymous hemianopia is a common and debilitating complication of post-chiasmal brain injury. Visual search training (VST) is a common compensation strategy used to improve object detection in the blind visual field. This review aims to synthesize the evidence regarding the effects of VST on quality of life, visual performance, and the characteristics of intervention protocols used across studies. This systematic review included randomized controlled trials, cohort studies, and quasi-experimental studies. Eligible studies were screened and data were extracted independently, and the risk of bias and intervention protocols were assessed. Eight studies met the eligibility criteria. Visual search training and related visual rehabilitation interventions are generally well tolerated, with no major safety concerns identified. Reported adverse events were predominantly mild, transient, and non-physical, and were more commonly associated with comparator interventions or logistical aspects of participation. More information on safety monitoring and standardized protocol is needed in future trials.

ABSTRAK

Hemianopia homonim merupakan komplikasi yang sering dan bersifat disabilitatif akibat cedera otak pasca kiasma. Visual search training (VST) merupakan salah satu strategi kompensasi yang banyak digunakan untuk meningkatkan kemampuan deteksi objek pada lapang pandang yang mengalami defisit. Penelitian ini bertujuan untuk melakukan tinjauan sistematis terhadap bukti efektivitas VST terhadap kualitas hidup, performa visual, serta karakteristik protokol intervensi yang digunakan pada masing-masing studi. Penelitian ini merupakan tinjauan sistematis terhadap studi uji acak terkontrol, kohort, dan kuasi-eksperimental. Setiap studi yang memenuhi kriteria inklusi dievaluasi risiko biasnya serta ditelaah secara deskriptif terkait protokol intervensi yang digunakan. Delapan studi memenuhi kriteria. Visual search training dan intervensi rehabilitasi visual terkait secara umum dapat ditoleransi dengan baik dan tidak menunjukkan adanya masalah keamanan yang bermakna. Efek samping yang dilaporkan sebagian besar bersifat ringan, sementara, dan non-fisik. Kejadian tidak diinginkan lebih sering dikaitkan dengan intervensi pembanding atau aspek logistik selama partisipasi penelitian, dibandingkan dengan intervensi VST itu sendiri. Diperlukan pelaporan yang lebih komprehensif mengenai pemantauan keamanan serta penggunaan protokol yang terstandarisasi pada penelitian-penelitian mendatang guna memperkuat bukti ilmiah terkait efektivitas dan keamanan visual search training pada pasien dengan hemianopia homonim.

Keywords:
homonymous hemianopia;
quality of life;
visual performance;
visual rehabilitation;
visual search training

INTRODUCTION

Homonymous hemianopia (HH) is a pervasive and debilitating consequence of post-chiasmal brain injury, characterized by loss of vision in the contralesional half of the visual field in both eyes. This condition affects approximately 30%

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of stroke survivors and often results in substantial impairment of quality of life.[1] The functional deficits associated with HH extend beyond mere visual loss; they frequently result in impaired mobility, an increased risk of falling, reading difficulties, and significant social isolation.[2] Clinical management of this condition remains variable, with only a small number of patients experiencing complete spontaneous improvement. Approximately 50% of patients show no improvement.[3]

Right now, there isn't a single, universally accepted rehab program for patients with homonymous hemianopia.[4] Clinical management relies mostly on complementary rehab strategies aimed at improving daily functioning rather than fixing the vision loss itself. Typically, these approaches involve three main methods: optical aids like glasses with prisms, eye-movement training to improve visual scanning, and restorative therapies designed to stimulate the edges of the blind field.[5,6,7] Treatment centers on three primary strategies: utilizing prism glasses, training patients in visual scanning techniques, and applying restorative therapies to stimulate the borders of the blind field.[5,6] Treatment centers on three primary strategies: utilizing prism glasses, training patients in visual scanning techniques, and applying restorative therapies to stimulate the borders of the blind field.[8] Recent longitudinal data have supported the efficacy of such compensatory training, suggesting that improvements in scanning and reading performance are practice-dependent and task-specific. Furthermore, evidence indicates that these functional gains are durable, persisting over long-term follow-up periods of up to 5 years, and are achievable regardless of the patient's age or comorbidities.[9]

However, protocols used across studies remain heterogeneous with respect to training duration, intensity, delivery method (paper-based versus computer-based), and supervision.[7,10] The SEARCH trial (2025), a large multicentre randomized controlled trial, evaluated the clinical effectiveness of VST compared with a sham training control involving slow tracking eye movements.[10] Contrary to the hypothesis that active scanning training would yield superior outcomes, the study found that both the VST and sham groups demonstrated comparable improvements in vision-related quality of life and visual scanning performance.[7,10,11] Therefore, this systematic review aims to evaluate and synthesize the existing evidence on the effectiveness of VST in improving visual performance and quality of life among patients with homonymous hemianopia and to analyze the variations in training protocols reported in previous studies.

MATERIAL AND METHODS

The study selection process was conducted using a structured and transparent approach in accordance with the PRISMA 2020 guidelines.[12,13] This systematic review was prospectively registered in the PROSPERO database under registration number CRD420261357795. The review followed a predefined methodology, including clearly defined eligibility criteria, systematic literature search, independent study screening, and structured data extraction to ensure methodological transparency and minimize potential bias during the review process.

The research question was developed using the PICO framework, which included adults with visual field defects, particularly homonymous hemianopia, due to neurological conditions such as stroke or traumatic brain injury as the population, visual search training as the intervention, Standard care, no treatment, sham training, or alternative rehabilitation as comparators, and outcomes comprising quality of life and visual performance, measured by validated instruments as primary outcome, and error rate, response time, and adverse event as secondary outcomes.[14] A comprehensive literature search was performed using ScienceDirect, PubMed, and Scopus.

To improve the indexing and retrieval of this article in biomedical databases, the keywords were aligned with standardized Medical Subject Headings (MeSH) terminology from the National Library of Medicine. The primary condition discussed in this review, homonymous hemianopia, corresponds to the MeSH term "Hemianopsia."[15] Because most cases of homonymous hemianopia are caused by post-chiasmal brain injury, particularly stroke, additional relevant MeSH terms include "Stroke" and "Brain Injuries."[2] The rehabilitation approach discussed in this review, visual search training, is conceptually related to the MeSH categories "Vision Rehabilitation," "Eye Movements," and "Saccades," which describe compensatory oculomotor training strategies used to improve visual scanning behaviour.[5,6] Outcome domains evaluated across the included studies, such as improvements in patient functioning and perception, correspond to the MeSH terms "Quality of Life," "Activities of Daily Living," "Reaction Time," and "Treatment Outcome." Although "Visual Search Training" is not currently recognized as an official MeSH descriptor, it was retained as a free keyword because it represents the specific intervention investigated in this systematic review. Grey literature was excluded. Manual reference list searching was not performed. Only studies published in peer-reviewed journals were considered eligible.

All identified records were imported into the Rayyan, which was used to assist with deduplication and blinded literature screening. Duplicate records were identified and removed by two reviewers (M and MYB). The remaining studies were then screened independently by two reviewers (FKS and PB) based on titles and abstracts using the Rayyan platform. Studies considered potentially eligible were subsequently retrieved and evaluated by the research team (PB, HRP, RAT, MH, and TW) through full-text review. The predefined inclusion and exclusion criteria were applied systematically to determine each study's final eligibility. Data extraction from the included studies was performed by M, MYB, and AFP using a standardized data extraction form. Disagreements during screening or eligibility assessment were resolved through discussion and consensus among the reviewers. If a consensus could not be reached, a third independent reviewer (DKM) was consulted for the final decision.

Risk of bias was independently assessed by two reviewers using the Revised Cochrane Risk of Bias Tool for Randomized Controlled Trials (RoB 2.0) and Risk of Bias in Non-randomized Studies – of Interventions (ROBINS-I) for Cohort and Quasi-Experimental Study, followed by critical appraisal to determine whether each study had a low risk, high risk, or some concerns regarding bias.[19]

RESULTS

The PubMed, Scopus, and ScienceDirect databases were searched by 2 independent researchers, and 88 studies were identified. Six duplicate records were removed. Furthermore, 11 studies were excluded due to incorrect study design, 32 due to studies that did not include a visual defect and were not related to visual search training, 25 due to irrelevant outcomes, and 6 due to unavailability of the full study. Ultimately, eight studies met the eligibility criteria and were included in the systematic review. The detailed screening process and the reasons for exclusion are shown in FIGURE 1, and the characteristics of each study are shown in FIGURE 1.

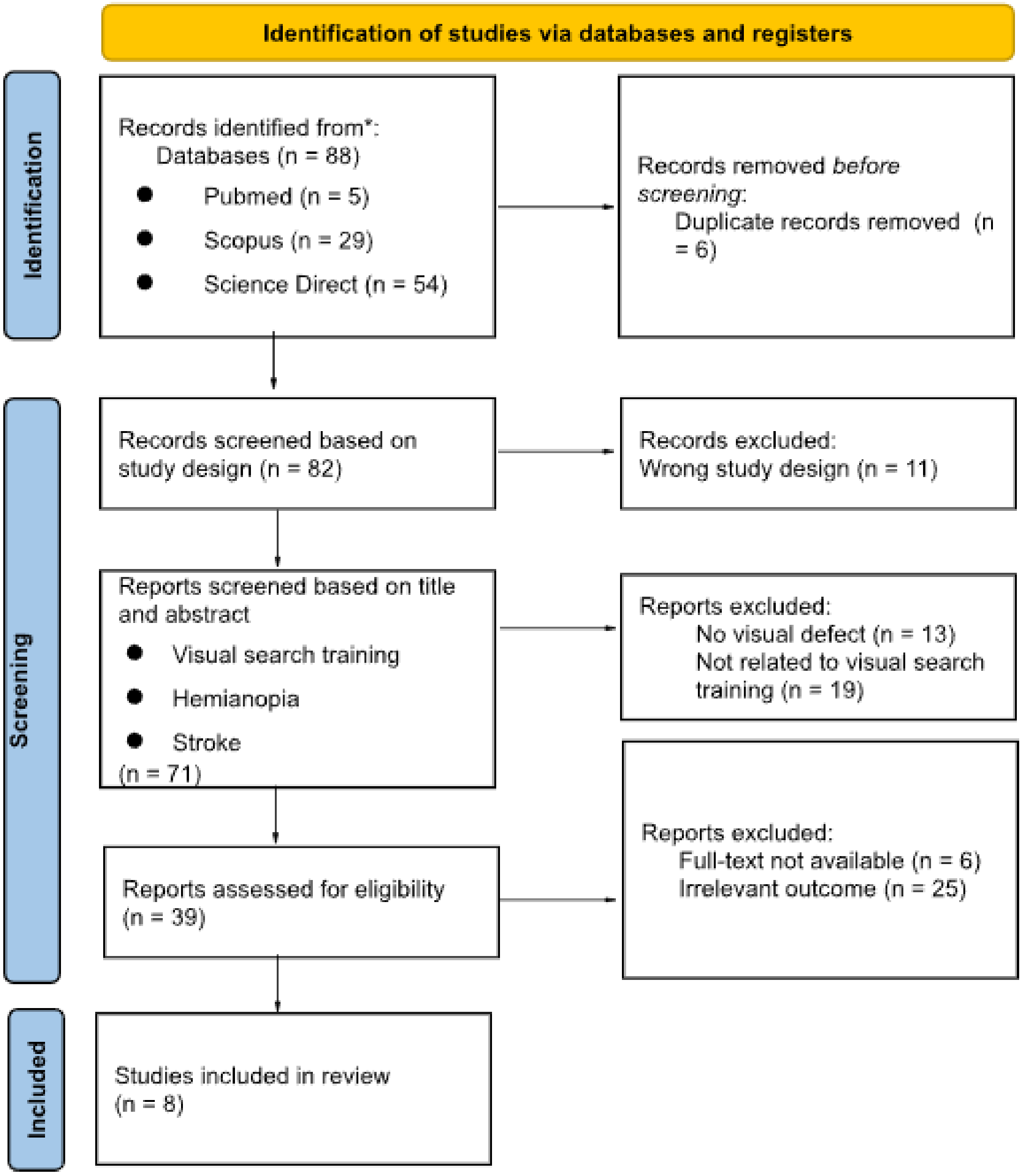

FIGURE 1. PRISMA flow-chart showing selection of articles for systematic review

The rigorous evaluation of Visual Search Training (VST) is anchored by a progression of randomized controlled trials (RCTs) led by Rowe and colleagues in the UK. The most significant contribution is the recent multicentre RCT by Rowe *et al.*,[10] which recruited 161 adult stroke survivors. This study represents the highest level of evidence in the review, designed to isolate the specific effects of scanning by comparing paper-based VST against a "sham" training control of slow eye movement tracking. This builds on previous groundwork, such as the pilot RCT by Rowe *et al.*[16] involving 87 participants, which proved it was feasible to compare VST with Fresnel prisms and standard care, It also incorporates a later secondary analysis by Rowe *et al.*[17] which provided a detailed breakdown of specific quality-of-life subscales within that same patient group. These studies track how VST transitioned from early pilot testing to large-scale efficacy trials (TABLE 1).

TABLE 1. Characteristics of the included studies

Author	Country	Study Design	Sample Size (N)	Mean Age (SD)	Population	Intervention	Duration	Comparator
Rowe *et al.*,[10]	UK	Multicentre RCT	161	VST: 68.3; Sham: 67.2	Adult stroke survivors with stable homonymous hemianopia	Paper-based Visual Scanning Training (VST)	6 weeks	Sham training (slow tracking eye movements)
Zihl *et al.*,[9]	Germany	Multiple N-of-1 design	97	58.9 (15.4)	Unilateral homonymous hemianopia	Saccadic training (Scanning & Reading)	Avg. 11-12 sessions	Advice group (general advice without specific training)
Sahraie *et al.*,[8]	World-wide (online)	Retrospective cohort	296	56.3 (17.1)	Hemianopia (post-stroke or traumatic brain injury)	NeuroEyeCoach™ (NEC)	Avg. 40 days	N/A (Pre vs. Post analysis)
Rowe *et al.*,[19]	UK	Secondary analysis of RCT	87	69 (12)	Stroke survivors with homonymous hemianopia	Visual search training	6 weeks	Fresnel prisms and standard care
Aimola *et al.*,[20]	UK	Randomized parallel-group	70	Int: 58.0; Control: 62.7	Chronic patients with HVFDs	Unsupervised computer training	~5 weeks	Attention-based training (Go/No-Go task)
Turton *et al.*,[21]	UK	Cohort study	9	Range: 54–84	Stroke survivors with visual field deficit	Goal-oriented Occupational Therapy	3 weeks	N/A (Before/ After comparison)
Rowe *et al.*,[16]	UK	Pilot RCT	85 VST (n = 30); Fresnel Prisms (n = 26); Standard Care (n = 29)	69.0 (11.8) VST (70.9 (11.2)); Fresnel Prisms (69.9 (12.9)); Standard Care (66.2 (11.3))	Post-stroke with stable homonymous hemianopia	Visual Search Training (VST)	Minimal 6 weeks, 12 weeks, 26 weeks	Fresnel Prisms and Standard care (information)
Jacquin-Courtois *et al.*,[22]	France & UK	Experimental (Proof-of-concept)	13	58.9 (15.6)	Chronic homonymous hemianopia	Ramp-step search paradigm	30 mins (Single session)	Healthy age-matched control group

RCT: randomized controlled trial; VST: visual search training; HVFD: homonymous visual field defects

Evaluating the Risk of Bias (RoB) across the four randomized controlled trials (RCTs) highlights a clear hierarchy in study quality, which makes drawing firm clinical recommendations difficult. Rowe *et al.*,[10] represents the most methodologically sound trial, largely due to its rigorous multicentre design and the use of a sham training control group.[10] Incorporating this specific design feature successfully blinded participants to their assigned groups, thereby reducing performance bias. This addresses a key limitation in the 2016 and 2019 studies by Rowe *et al.*,[16] where comparing VST against visible Fresnel prisms made blinding impossible (FIGURE 2).[19] The trial by Aimola *et al.*,[20] carries a high risk of attrition bias due to a 20% dropout rate caused by technical difficulties with the unsupervised computer training, despite using an active attention-control group (FIGURE 3).

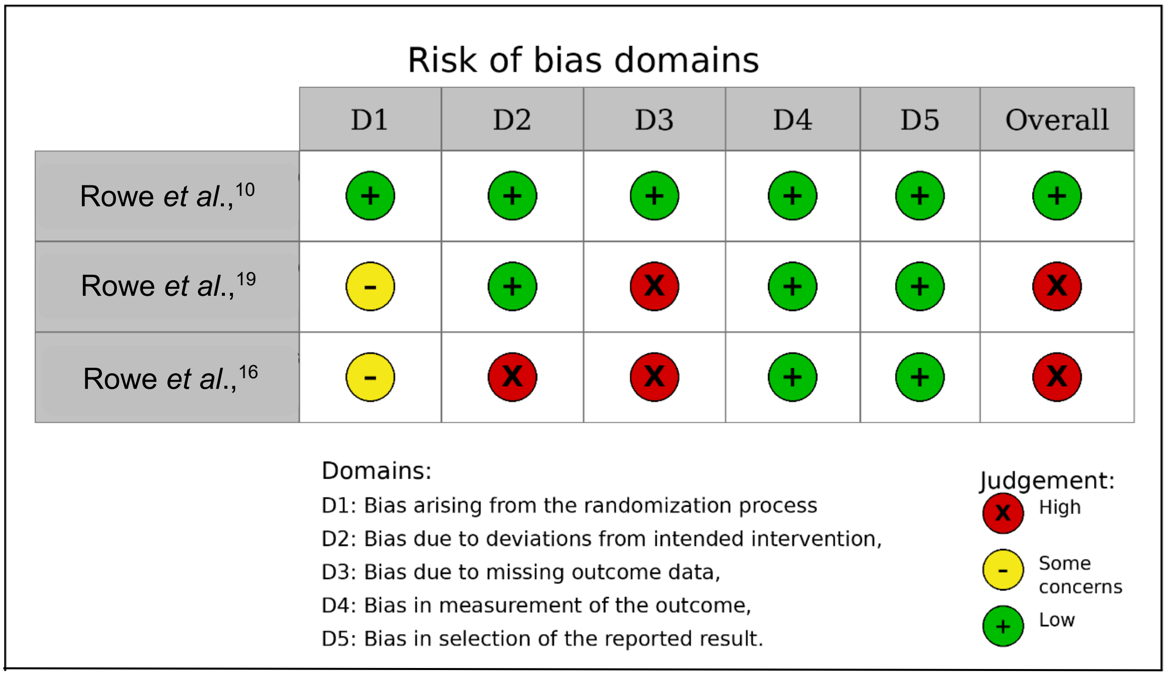

FIGURE 2. Risk of Bias (RoB 2.0) for the intention-to-treat analysis

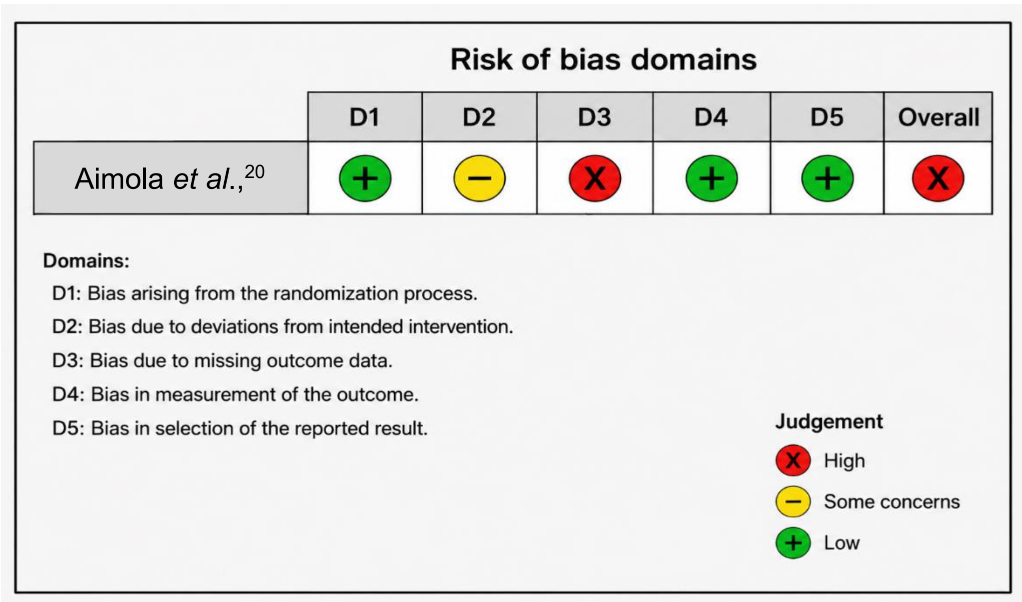

FIGURE 3. RoB 2.0 of Per-Protocol Analysis

The clinical utility of Rowe *et al.*,[10] remains complicated; despite its methodologically robust protocol, the paper-based Visual Search Training (VST) failed to demonstrate superiority over sham training regarding quality of life or visual search speed.[10] The higher-risk protocol by Aimola *et al.*,[20] demonstrated a statistically significant 12.9% improvement in reaction time following computer-based stimulation. These findings indicate that while the paper-based protocol underwent rigorous testing, it likely lacks the stimulus intensity necessary to drive true visual recovery. In contrast, the computer-based protocol is more effective but harder to implement due to technical barriers (FIGURE 3). Ultimately, the choice of the "most promising" protocol must balance efficacy with safety. While Rowe *et al.*,[10] showed no functional advantage of VST over sham, the study confirmed the intervention's safety. This finding has important clinical implications, compared with Rowe *et al.*,[16] in which the Fresnel prism comparator group experienced frequent adverse events, such as headaches and disorientation. Therefore, the synthesized evidence recommends adaptive computer-based training as seen in Aimola *et al.*,[20] and supported by cohort data from Sahraie *et al.*,[8] as the most effective method for driving visual improvements, provided that adequate technical support is available to prevent the high attrition rates associated with unsupervised therapy. The risk of bias of the included studies was assessed using the Cochrane Risk of Bias 2.0 (RoB 2.0) tool for randomized controlled trials (FIGURE 2 and FIGURE 3) and the Risk Of Bias In Non-randomized Studies of Interventions (ROBINS-I) tool for cohort and quasi-experimental studies (FIGURE 4).[17,18] For randomized trials analyzed using the intention-to-treat approach, one study demonstrated a low overall risk of bias. In contrast, the remaining studies were judged to have a high risk of bias, primarily driven by concerns about missing outcome data and selective reporting. In the per-protocol analysis, the included randomized study was rated as having a high overall risk of bias, mainly due to missing outcome data despite low risk in randomization, outcome measurement, and reporting domains.

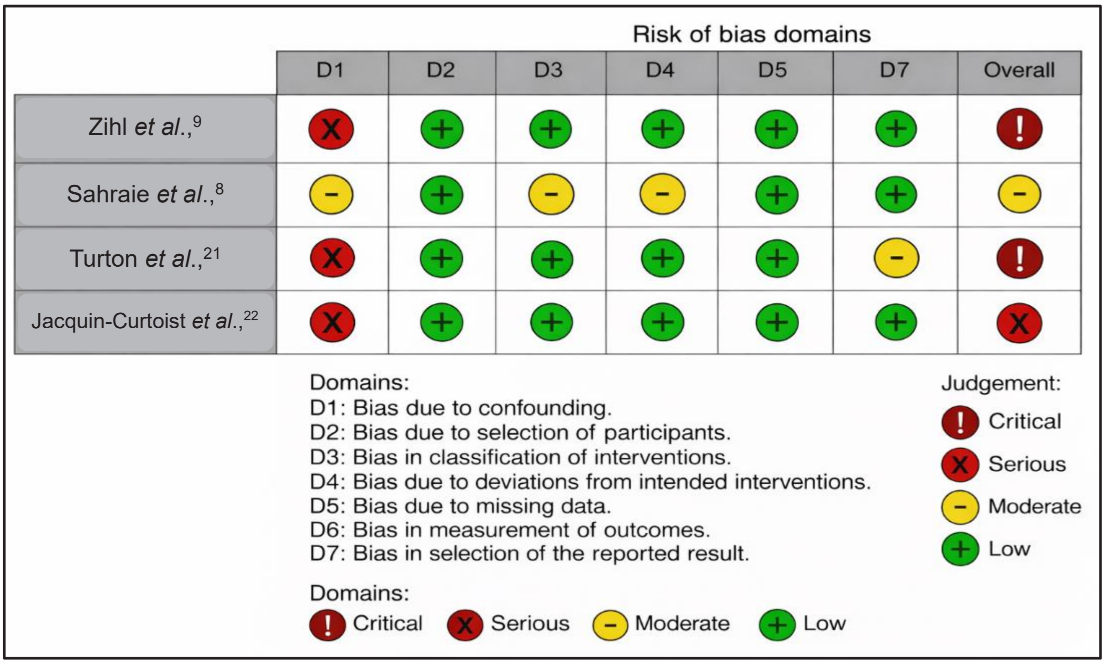

FIGURE 4. Risk of Bias analysis of cohort and quasi-experimental studies

For cohort and quasi-experimental studies assessed using ROBINS-I, the overall risk of bias ranged from moderate to critical.[18] Most studies showed low risk of bias in domains related to participant selection, classification of interventions, deviations from intended interventions, and outcome measurement. However, a serious to critical risk of bias was frequently identified in the confounding domain, and in some studies, in the selection of reported results. Overall, these findings suggest that although several studies demonstrated methodological strengths in outcome assessment and intervention classification, the presence of confounding factors, missing data, and selective reporting may limit the certainty of the evidence.

Based on the interpretation of the RoBINS-I framework (Risk of Bias in Non-randomized Studies - of Interventions) applied to the cohort data, the adaptive computer-based protocol, specifically the NeuroEyeCoach™ model used by Sahraie *et al.*,[8] and the systematic training by Zihl *et al.*,[9] emerges as the most promising protocol for clinical implementation. While the randomized trials for paper-based methods Rowe *et al.*,[10] demonstrated a low risk of bias but yielded null clinical results, the non-randomized studies for computer-based training provided robust evidence of efficacy, with a high responder rate of 87% and durable gains lasting up to five years.[10] Incorporating dynamic, moving targets may make this protocol more advantageous by forcing active oculomotor adaptation. In contrast, static paper-based methods suffer from a ceiling effect and fail to exceed placebo outcomes.

The primary outcome criteria in the systematic review were quality of life and clinical improvement, which are summarised in TABLE 2. The synthesis of evidence on quality of life reveals a clear divergence between patient-reported improvements observed in observational studies and outcomes reported in well-controlled, placebo-controlled trials. Visual Search Training (VST) has been widely associated with improved quality of life (QoL), specifically reductions in perceived dependency.[23]

TABLE 2. Data extraction of quality of life and clinical improvement outcomes

Author	Intervention + Co-Intervention	Comparator	Quality of Life Outcomes	Statistical Significance	Visual Performance Outcomes	Statistical Significance
Rowe *et al.*,[10]	Paper-based VST + Standard clinical input	Sham training (slow eye movement tracking)	NEI-VFQ 25: Composite scores improved in both groups, but VST was not superior to Sham.	$p = 0.141$	Clinical: Both groups improved search speed (VST: 12.5%, Sham: 10.6%), but VST was not superior.	Scanning speed $p = 0.128$; Scanning accuracy $p = 0.266$)
Zihl *et al.*,[9]	Scanning & Reading Training + Verbal feedback	Advice group (Waitlist)	Subjective Competence (IM-Q): Significant reduction in visual complaints and improved ADL competence.	$p < 0.001$	Clinical: Improvements in scanning and reading were maintained at 5-year follow-up.	$p < 0.001$
Sahraie *et al.*,[8]	NeuroEyeCoach™	Pre-vs Post-training	Subjective Disability (SD): Patient-reported visual disability score decreased significantly.	$p < 0.001$	Clinical: High Responder Rate. 87% of patients showed quantifiable improvement in search reaction times.	$p < 0.001$

TABLE 2. Cont...

Author	Intervention + Co-Intervention	Comparator	Quality of Life Outcomes	Statistical Significance	Visual Performance Outcomes	Statistical Significance
Rowe *et al.*,[19]	Visual Search Training + Neuro 10 supplement eval	Fresnel Prisms / Standard Care	NEI-VFQ 25 (Subscales): Improvement in "Dependency" and "Distance Activities" subscales.	$p < 0.001$	N/A	N/A
Turton *et al.*,[21]	Goal-oriented OT + Strategy education	Pre- vs Post-Intervention	NEI-VFQ 25: Composite score improved for the majority of participants.	N/A	Clinical: All participants reported improved awareness and attention to the blind side during activities following the intervention.	N/A
Rowe *et al.*,[16]	Visual Search Training (VST) + Info leaflets	Fresnel Prisms / Standard Care	NEI-VFQ 25: Total score improved significantly more in the VST group than controls.	$p = 0.05$	Clinical: Visual field size did not increase (0% expansion).	N/A
Aimola *et al.*,[20]	Unsupervised computer training + Visual acuity correction	Attention-based training	ADL Questionnaire: Subjective improvement in reading and daily activities.	$p < 0.05$	Clinical: Improved computer search speed did not result in better walking/ mobility performance.	$p < 0.05$

QoL: quality of life; VST: visual search training; NEI-VFQ: National Eye Institute Visual Functioning Questionnaire; IMQ: Interpersonal Mindfulness Questionnaire; ADL: activity of daily living

TABLE 3. Data extraction of error rate outcomes

Author	Intervention + Co-Intervention	Comparator	Result (Error Rate/Accuracy)	Statistical Significance
Rowe *et al.*,[10]	Paper-based VST + Standard clinical input	Sham training (slow eye tracking)	Both groups improved accuracy slightly, but VST was not superior to Sham.	$p > 0.05$
Zihl *et al.*,[9]	Scanning & Reading Training + Verbal feedback	Advice Only (Control)	Number of omissions (missed targets) decreased significantly in both scanning and reading tasks.	$p < 0.001$
Sahraie *et al.*,[8]	NeuroEyeCoach™	Pre- vs Post-training	Errors decreased from ~14% (pre) to ~9% (post) in detection tasks.	$p < 0.001$
Turton *et al.*,[21]	Goal-oriented OT + Strategy education	Pre- vs Post-Intervention	Star Cancellation Test accuracy was 100% before treatment for all participants.	N/A
Aimola *et al.*,[20]	Unsupervised computer training + Visual acuity correction	Attention-based training	Search accuracy improved in the intervention group compared to control.	$p < 0.05$
Jacquin-Courtois.[22]	Ramp-step paradigm	Healthy Controls	Number of prediction errors was low and did not change between sessions.	Not Significant

VST: visual search training; OT: occupational therapy

The analysis of error rates across the included studies reveals a fundamental divergence in efficacy driven by the nature of the training protocol. In studies using static, paper-based interventions, such as those by Rowe *et al.*,[10] and Turton *et al.*,[21] the error rates were largely inconclusive due to a “ceiling effect.” Participants in these trials exhibited near-perfect accuracy at baseline because static tasks allow compensatory head movements and unlimited search time, failing to challenge the oculomotor system to induce measurable adaptations sufficiently. Studies employing dynamic, computer-based protocols demonstrated significant functional gains, with Zihl *et al.*,[9] reporting a marked reduction in omission errors. Their data indicate that patients successfully expanded their effective visual field into the blind hemispace. Sahraie *et al.*,[8] observed a simultaneous decrease in detection errors and reaction times, which confirms that dynamic training improves oculomotor efficiency. These contrasting outcomes suggest that the reduction in errors reflects neurological reorganization driven by the specific nature of the stimuli, rather than a shift in behavioral strategy.

Data extraction for response time—defined here as the time required for a patient to locate a target—is summarized in TABLE 4. Synthesizing these findings indicates that Visual Search Training (VST) consistently accelerates visual processing speed and shortens saccadic latency. Large-scale observational studies[8,9] report robust and significant reductions in search times, indicating that patients can effectively learn to scan their environment more efficiently.

TABLE 4. Data extraction of response time

Author	Intervention + Co-Intervention	Comparator	Result (Error Rate/Accuracy)	Statistical Significance
Rowe *et al.*,[10]	Paper-based VST + Standard clinical input	Sham training (slow eye tracking)	VST group improved search speed by 12.5%; Sham group by 10.6%.	$p = 0.141$
Zihl *et al.*,[9]	Computer-based Scanning/Reading + Verbal feedback	Advice Only (Waitlist)	Mean scanning duration decreased (became faster) for both simple and complex arrays.	$p < 0.001$
Sahraie *et al.*,[8]	NeuroEyeCoach™	Pre- vs Post-training	Average reaction time decreased from ~3.3s (pre) to ~2.5s (post).	$p < 0.001$
Turton *et al.*,[21]	Goal-oriented OT + Strategy education	Pre- vs Post-Intervention	Time taken to search a real-world room decreased for some but increased for others.	N/A
Aimola *et al.*,[20]	Unsupervised computer training + Visual acuity correction	Attention-based training	The intervention group showed a 12.9% improvement in Reaction Time (RT) vs. negligible change in control.	$p < 0.05$
Jacquin-Courtois.[22]	Ramp-step paradigm	Healthy Controls	Saccadic latency (time to initiate eye movement) reduced significantly to near-normal levels.	$p < 0.003$

TABLE 5. Data extraction of adverse event

Author	Intervention	Comparator	Result (Adverse Events)
Rowe *et al.*,[6]	Paper-based VST	Sham training	SAEs included recurrent stroke or cancer, typical for this elderly population. The visual search training itself caused no reported physical harm or safety incidents.
Turton *et al.*,[22]	Goal-oriented OT	N/A	One participant reported anxiety about traveling to the hospital, another reported fatigue.
Rowe *et al.*,[10]	Visual Search Training (VST)	Fresnel Prisms / Standard Care	The Prism group reported frequent headaches, eye strain, and confusion/disorientation. The VST group reported no specific physical side effects, though some noted the training was boring/repetitive.

Adverse events associated with visual search training and related rehabilitation interventions were infrequently reported and generally mild. Overall, no serious adverse events were directly attributed to the visual rehabilitation interventions themselves across the included studies.[10] In the randomized controlled trial by Rowe *et al.*,[10] serious adverse events such as recurrent stroke or cancer were reported; however, these events were considered typical for the elderly study population and were not related to the visual search training intervention. Importantly, no physical harm or safety incidents directly attributable to the paper-based visual search training were identified, suggesting that the intervention was safe from a clinical standpoint.[24]

Similarly, in the study by Turton *et al.*,[21] no serious adverse events were reported related to the intervention. The adverse experiences described were limited to non-physical effects, with one participant reporting anxiety about traveling to the hospital and another reporting fatigue. These findings indicate that the observed adverse effects were more likely associated with participation burden rather than the therapeutic content of the intervention. In contrast, Rowe *et al.*,[16] reported frequent minor complaints in the comparator group receiving Fresnel prisms, including headaches, eye strain, and confusion or disorientation. Safety assessments revealed no specific side effects within the VST cohort, though several participants reported that the highly repetitive exercises became tedious over time. This feedback highlights a challenge regarding patient engagement rather than intervention safety.

DISCUSSION

Systematic review of the current evidence indicates that Visual Search Training (VST) serves as a safe, viable, and well-tolerated compensatory rehabilitation strategy for patients with homonymous hemianopia. Implementation of VST significantly enhances visual scanning behaviour, curtails reaction times within the blind hemifield, and improves vision-related quality of life alongside functional independence. Clinical outcomes remain highly dependent on the specific training protocol utilized. Adaptive, computer-based interventions featuring dynamic stimuli consistently yield more robust, durable gains than static or paper-based alternatives. Substantial heterogeneity in training duration, intensity, and delivery methods across the literature underscores the critical lack of a universally standardized VST protocol.

Zihl *et al.*,[9] employed a multiple N-of-1 design with 97 patients in Germany, embedding a five-year follow-up period to confirm that systematic scanning and reading training produce lasting functional gains independent of aging. Sahraie *et al.*,[8] provided real-world evidence through a large retrospective cohort study involving 296 patients across the UK, Germany, and the USA. Evaluation of the commercially available NeuroEyeCoach™ program revealed that standardized, adaptive computer therapy achieves high responder rates across a diverse demographic of stroke and traumatic brain injury patients (TABLE 1).

Targeted investigations involving smaller cohorts have explored specific mechanisms of recovery alongside novel delivery methods, moving beyond broad efficacy trials. Aimola *et al.*,[20] conducted a randomized parallel-group trial (N=70) that rigorously controlled for the effects of attention by comparing unsupervised computer-scanning training with an attention-based "Go/No-Go" task, confirming that spatial scanning, rather than general alertness, contributes to recovery. Turton *et al.*,[21] introduced a functional approach by integrating scanning training directly into meaningful daily activities through goal-oriented occupational therapy. This pilot study (N=9) successfully shifted the therapeutic focus away from abstract visual drills. Jacquin-Courtois *et al.*,[22] provided proof-of-concept experimental evidence (N=13), that oculomotor plasticity can occur rapidly. Their data show that a single 30-minute session of targeted "ramp-step" training is sufficient to induce significant changes in saccadic latency (TABLE 1). These eight studies span a broad research spectrum, linking short-term mechanistic experiments with long-term evaluations of clinical effectiveness.

Visual Search Training (VST) demonstrates a superior physical safety profile compared to optical aids. Documented adverse events for VST are strictly behavioral and logistical—specifically mental fatigue, boredom, and technical frustration—which can elevate study attrition rates. Rowe *et al.*,[16] noted headaches, eye strain, and disorientation among optical aid users, whereas VST cohorts remained entirely free of physical symptoms. Mitigating VST fatigue and maintaining patient adherence requires short, structured sessions coupled with adaptive, gamified software to reduce boredom. Addressing the high dropout rates (20%) documented in unsupervised protocols Aimola *et al.*,[20] relies on dedicated technical support and onboarding supervision to build patient operational confidence.

Tabular data extraction followed the risk-of-bias analysis, prioritizing parameters reported consistently across multiple studies. The resulting dataset isolates the specific effects of visual search training on patient quality of life and visual performance. Extracted variables included quality of life, clinical improvement indices, error rates, response times, and adverse events.

Effect of VST on the quality of life and clinical improvement

Early evidence from observational studies[8,21] and pilot experiments[16,20] indicated that VST significantly outperformed standard interventions. Supporting evidence from Zihl *et al.*,[9] and Sahraie *et al.*,[8] demonstrates that systematic visual training yields measurable, sustained functional improvements. Zihl *et al.*,[9] reported a significant reduction in patient-reported difficulties with daily living activities, a benefit that remained stable at a five-year follow-up. Similarly, Sahraie *et al.*,[8] demonstrated a significant decrease in Subjective Disability scores, directly correlating objective improvements in visual search velocity with reduced patient-perceived functional impairment.[8] Recent high-quality data from Rowe *et al.*,[10] challenge the therapeutic specificity of VST, demonstrating its statistical equivalence to a sham intervention and suggesting that non-specific factors, such as clinician attention, drive these outcomes. The treatment retains a substantial clinical impact within the 'Dependency' and 'Distance Activities' domains Rowe *et al.*,[19] with longitudinal data confirming that improved patient confidence remains stable at a five-year follow-up Zihl *et al.*,[9] These studies highlight a clear divergence between subjective and objective outcomes, where patients frequently report enhanced safety and independence despite a lack of corresponding statistical improvement in objective mobility tasks.[24]

Methodological heterogeneity across intervention protocols and outcome measurements complicates the interpretation of cumulative data. Training modalities span a broad spectrum, ranging from static, paper-based search cards Rowe *et al.*[10] and Rowe *et al.*,[16] to dynamic, adaptive digital programs Sahraie *et al.*,[8] and Zihl *et al.*[9] This variability likely explains the conflicting results, as dynamic computer stimuli elicit more effective active oculomotor adaptation than static targets. Inconsistent outcome metrics further complicate data synthesis; while the NEI-VFQ 25 remains the standard instrument for vision-related quality of life Rowe *et al.*,[19] it may lack the diagnostic sensitivity required to capture discrete hemianopic deficits compared to the custom ADL scales developed by Aimola *et al.*,[20] o or the subjective competence ratings employed by Zihl *et al.*[9] This disconnect suggests that generic instruments obscure the practical functional gains of training, which are otherwise captured by targeted behavioral measures.

Clinical improvement outcomes were evaluated across the included studies using a range of performance-based measures, including visual search speed, reaction time, and visual field-related function, alongside validated patient-reported quality of life metrics. Although visual search training (VST) aims to optimize scanning behaviour to enhance detection velocity and accuracy, the extent to which these laboratory gains translate into improved activities of daily living (ADL) remains unclear. To address these mechanics, the evaluated VST protocol stimulated a 30° visual field bilaterally from fixation, requiring participants to execute structured voluntary saccades without time constraints or supplementary cues. In contrast, many computer-based scanning programs incorporate temporal demands, which may enhance training effects. A randomized controlled trial Gupta *et al.*,[25] using computer-generated visual scanning tasks has demonstrated significant improvements in visual search performance and quality of life. Overall, the findings indicate that visual rehabilitation interventions, including visual search training (VST) and related strategies, may lead to measurable clinical improvements; however, the magnitude and consistency of these effects varied across intervention type, comparator, and outcome domain.

Several studies demonstrated favorable clinical improvement following structured visual rehabilitation. Zihl *et al.*,[9] reported significant and durable improvements in scanning and reading performance after computer-based scanning and reading training with verbal feedback, with gains maintained at a 5-year follow-up. This long-term maintenance suggests that compensatory visual strategies, when reinforced with active feedback, may induce sustained functional adaptation rather than short-lived performance gains. Similarly, Sahraie *et al.*,[8] reported a high responder rate following NeuroEyeCoach™ training, with 87% of participants demonstrating quantifiable improvements in visual search reaction times, which supports the efficacy of targeted, repetitive visual search exercises in enhancing visual processing efficiency. Importantly, the presence of spatial neglect in patients with hemianopia does not appear to preclude the therapeutic benefits of visual search training. This finding is clinically significant, as individuals with concomitant hemianopia and neglect typically exhibit the most severe impairments in visual search performance and activities of daily living.[26]

Evidence supporting clinically meaningful improvements was also reported in studies that employed patient-centered functional scales. Rowe *et al.*,[19] observed improvements exceeding the minimal clinically important difference of 10 points in the Dependency and Distance Activities subscales of the NEI-VFQ-25 following VST. These data indicate that targeted visual training can yield measurable advancements in functional independence and mobility-related tasks. Turton *et al.*,[21] demonstrated that most participants undergoing goal-oriented occupational therapy combined with strategy education achieved clinically meaningful improvements on the NEI-VFQ-25. The lack of a concurrent control group precludes definitive causal attribution.

Multiple comparative studies report negligible or statistically non-significant clinical differences when VST is evaluated against active or sham control interventions. In a randomized controlled trial by Rowe *et al.*,[10] both the experimental VST and sham training cohorts demonstrated equivalent post-intervention gains in visual search velocity. The lack of a statistically significant intergroup variance indicates that VST offers no distinct therapeutic advantage over sham protocols. Rowe *et al.*,[16] reported that although VST failed to expand visual field dimensions, the intervention demonstrated that compensatory training can optimize functional performance independently of underlying perimetric deficits.

Aimola *et al.*,[20] reported that unsupervised computer-based training improved visual search speed without translating into real-world mobility benefits. Evaluation via objective walking performance tests revealed no corresponding advancement in functional ambulation. Measurement discrepancies reveal a distinct dissociation between laboratory-based psychophysical metrics and real-world functional outcomes. Low-intensity or unsupervised training paradigms appear particularly vulnerable to this transfer deficit.[27] Diminished effect sizes within unsupervised protocols likely stem from variations in task sensitivity and reduced training density across protracted intervention schedules. Inter-component task interference, coupled with the absence of clinical oversight and real-time performance feedback, further dampens participant motivation and overall therapeutic efficacy.[28,29]

Impact of VST on Performance Accuracy and Error Rates

Anatomical data indicate that dynamic computer-based training outperforms static paper-based methods by leveraging spared subcortical pathways that bypass the damaged primary visual cortex (V1).[30] Hemianopia typically results from primary occipital lobe injury. The phylogenetically older retinotectal pathway, routing directly from the retina to the superior colliculus within the midbrain, frequently remains intact. This midbrain structure specializes in processing dynamic stimuli, such as abrupt visual onsets or moving targets, and mediates the generation of reflexive saccadic eye movements.[31] Dynamic training exploits this bottom-up attentional mechanism, wherein moving visual stimuli automatically engage the superior colliculus and motion-sensitive regions of the dorsal stream, such as area V5/MT. This engagement drives reflexive, rapid saccades into the hemianopic field. In contrast, static paper-based targets rely heavily on top-down cortical processing and the ventral stream, pathways severely compromised by V1 lesions. By repeatedly stimulating these motion-sensitive subcortical structures, dynamic training effectively drives functional remodeling within oculomotor command centers—specifically the frontal eye fields—enabling the automatic initiation of larger, more precise saccades into the blind field to capture targets undetected by the damaged visual cortex.[32]

Effect of VST on response time

Cumulative data from the included studies demonstrate that VST consistently accelerates visual processing speed and reduces saccadic latency, a conclusion further corroborated by smaller experimental trials,[22,27] demonstrating rapid reductions in reaction time that significantly outperformed both attention-control groups and baseline values. Recent randomized controlled data challenge the consistency of this therapeutic benefit,[10] demonstrating that while VST cohorts improved their processing speed, their outcomes were not statistically superior to those of a sham control group. This equivalence suggests that observed improvements may be driven by a generalized practice effect. Crucially, observational data reveal that accelerated visual search velocity is not universal; some patients deliberately reduce their response times to prioritize accuracy over speed within complex real-world environments.[21]

Visual Search Training (VST) leads to significantly faster visual processing and reduced reaction times across various protocols. Large-scale cohort data from Sahraie *et al.*,[8] revealed a uniform reduction in reaction time from an average of 3.3 seconds to 2.5 seconds, confirming that patients become more efficient at locating targets without sacrificing accuracy. Similarly, Zihl *et al.*,[9] reported a significant decrease in scanning duration for both simple and complex arrays, with benefits transferring to reading tasks. Patients demonstrated faster, more accurate visual search performance, with improvements observed for targets presented in both the intact and the blind visual fields.[33] Notably, post-training performance in the blind field matched or even exceeded pre-training performance in the sighted field. In contrast, the only other published study evaluating an online visual search training program reported improvements confined to the blind field, with no corresponding changes in performance within the sighted field.[34]

These findings raise important questions regarding the contribution of eye movements to performance gains observed following training. Improvements may reflect practice-dependent adaptations within the oculomotor system itself, as well as the involvement of higher-order mechanisms such as the development of more efficient gaze strategies or perceptual learning.[35,36] The primary mechanism driving this acceleration is practice-dependent oculomotor adaptation facilitated by the cumulative effect of repeating sessions. Initially, hemianopia patients exhibit “sluggish” or hypometric saccades due to the loss of primary visual input. Continuous recalibration of the oculomotor system is driven entirely by the repetitive nature of this training. Jacquin-Courtois *et al.*,[22] demonstrated the rapid nature of this plasticity, showing that a single intensive session significantly reduces saccadic latency and confirming that motor planning centers—specifically the superior colliculus and frontal eye fields—can quickly bypass the damaged visual cortex to initiate faster eye movements. Repeated active stimulation systematically consolidates into a stable, optimized scanning strategy Aimola *et al.*,[20] and Zihl *et al.*,[9] This progression transitions the visual search from an effortful, top-down task into an automated, reflexive motor behaviour characterized by increased velocity. The equal improvement across both the VST and sham arms in the Rowe *et al.*,[10] trial underscores that repeated engagement with any structured visual task induces a general practice effect capable of sharpening temporal processing speed.

Adverse events

No instances of visual deterioration or serious neurological complications occurred. Successfully mitigating the minor behavioral barriers associated with VST requires structured clinical workflows that include early technical support and scheduled compliance monitoring.[37] Precluding the physical side effects of headaches and disorientation frequently associated with optical devices,[16] clinicians may consider VST the primary intervention over Fresnel prisms, particularly for patients highly sensitive to visual confusion. Managing the 20% attrition rate observed in unsupervised computer-based protocols requires robust initial training alongside ongoing technical support to prevent user frustration.[10] Managing the cognitive fatigue and boredom associated with repetitive scanning tasks requires structuring therapy sessions into short, frequent intervals rather than prolonged blocks.[21] Utilizing adaptive, gamified software can further sustain patient motivation and adherence throughout the rehabilitation process.[8]

These findings do not rule out the therapeutic utility of VST for individuals with hemianopia. Post-diagnosis care should routinely include the distribution of clear, accessible vision-related information through standardized channels, including printed clinical literature and verified online platforms.[26]

Clinical correlation

Physiological improvements observed following VST—specifically reduced reaction times in the blind hemifield and expanded saccadic amplitudes—translate directly into functional gains during activities of daily living (ADLs). Homonymous hemianopia severely compromises safe mobility, reading proficiency, and spatial navigation, frequently causing collisions and a subsequent loss of patient independence. Active training of compensatory scanning eye movements allows VST to target and mitigate these specific functional deficits. Visual Search Training (VST) equips patients with the behavioral strategies necessary to safely navigate their environment and reduce collision risks, improving overall confidence and quality of life despite not restoring the damaged visual field.

Study limitations

This review has several limitations. First, substantial heterogeneity existed among the included studies in terms of training protocols, including differences in duration, intensity, delivery methods, and supervision, which limits direct comparability between studies.Second, outcome measures varied across studies, including patient-reported quality-of-life scales and performance metrics such as reaction time and error rates. Third, high-quality RCTs were limited, with some studies employing observational or quasi-experimental designs. A meta-analysis was not conducted due to methodological and clinical heterogeneity that could lead to unreliable estimates. Patients with severe cognitive deficits, aphasia, or significant physical disabilities—which are frequent comorbidities in real-world stroke populations—were often excluded from these trials. These strict selection criteria limits the generalizability of the findings, as implementing demanding or intensive VST protocols might be significantly more challenging in a broader, more complex clinical setting. In addition, grey literature was not included, which may increase the risk of publication bias. Finally, manual reference list searching was not conducted, which may increase the risk of missing some potentially relevant studies outside the primary database search.

CONCLUSION

The synthesized evidence indicates that VST is a safe, viable, and well-tolerated rehabilitation strategy for homonymous hemianopia. Rehabilitation should therefore primarily focus on compensatory strategies to improve visual scanning and functional independence rather than on restoring the visual field. However, the efficacy of VST depends on the specific training protocol employed. Adaptive computer-based protocols utilizing dynamic stimuli have demonstrated more robust and durable improvements in visual search speed, reaction time, and vision-related quality of life. For clinical practice, VST should be integrated into standard neuro-rehabilitation programs to help patients regain independence in daily activities. Future research should focus on standardizing these dynamic training protocols, conducting larger randomized controlled trials, and developing support systems to reduce technical barriers and improve adherence, particularly among elderly patients.

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