

Effectiveness of technology-based interventions on visual recovery and functional outcomes in stroke patients with visual deficits – a rapid systematic review

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ABSTRACT

Vision, encompassing visual scanning, perception, acuity, convergence, and tracking, is crucial for daily functioning. Visual deficits, such as those acquired post-stroke, can significantly impair independence in Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs). Approximately 65% of stroke survivors experience visual changes, including homonymous hemianopia, quadrantanopia, and scotoma. These deficits impact visual perception and function, leading to increased rehabilitation stays, heightened fall risk, reduced independence, and decreased likelihood of returning home. This rapid systematic review examined the effectiveness of technology-based interventions for visual rehabilitation post-stroke. A literature search was conducted across PubMed, PsycINFO, and CINAHL for studies published from 2014 to 2024. Inclusion criteria required studies to involve adults with post-stroke visual deficits and assess technology-based interventions. Ten studies were included, categorized by intervention modality (traditional computer-based vs. advanced individualized technologies), dosage (high vs. low), and intervention setting (clinic vs. home). Results highlighted the effectiveness of both traditional and advanced technology interventions in improving visual outcomes such as visual field, acuity, and visuospatial perception. High-dosage and low-dosage interventions showed comparable benefits, suggesting that lower dosages may be equally effective while less resource-intensive. Clinic-based interventions consistently yielded positive outcomes, while home-based interventions demonstrated more variable results. The findings suggest that lower-cost, traditional technology-based approaches may provide outcomes comparable to advanced technologies, supporting their continued use in resource-constrained settings. Clinical delivery of interventions is recommended for optimal outcomes. Limitations include the small sample size of included studies and limited high-level evidence, underscoring the need for further research into technology's role in vision rehabilitation. This review emphasizes the importance of incorporating technology into occupational therapy interventions for post-stroke visual deficits, particularly in clinical settings.

INTRODUCTION

Vision, encompassing visual scanning, perception, acuity, convergence, and tracking, is an essential mechanism for daily functioning, where visual deficits can play an essentially debilitating role in daily life. Acquired visual deficits can lead to reduced independence in both Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs) [1]. About 65% of individuals who had a stroke also experienced changes in their vision, including, but not limited to, homonymous hemianopia, quadrantanopia, and scotoma [2]. All these conditions listed impact vision by impacting vision itself, such as blind spots, or the perception of vision, such as visual neglect of certain eye quadrants. Most people who experience some form of vision loss do not typically regain full visual function, but rehabilitation, such as occupational therapy, can assist with some functional recovery [2]. In addition to the functional implications of visual changes following a stroke, various lifestyle changes should be considered. Visual neglect following a stroke has implications with longer rehabilitation stays, increased risk for falls, a decrease in functional independence, and a lower likelihood of being discharged home following a hospital or inpatient rehabilitation stay [3].

A therapist's role in assisting with visual changes includes increasing awareness on both sides of the patient's environment by use of cueing, visual scanning, the use of low vision devices, problem-solving skills, and education on low vision resources to promote performance of ADLs and IADLs [3, 4]. An occupational therapist can play a key role in helping to improve visual deficit symptoms and educate the client on environmental adaptations and compensatory strategies to improve daily function [5]. Technology-based visual interventions are widely used but not always linked to functional return of vision regarding engagement in occupations. Current research reflects a trend toward more advanced technologies for visual rehabilitation to improve visual deficits [6]. However, visual rehabilitation is

typically a multicomponent intervention, including environmental modifications, problem-solving strategies, training on adaptive devices, technology interventions, and training specific to ADLs and IADLs [4]. This review will highlight the benefit of more advanced technologies in improving functional outcomes and reducing visual deficits.

METHODS

Literature search and screening criteria

Three databases were searched in June 2024: PubMed, PsychoINFO, and CINAHL. These databases were utilized because the research included in those databases discusses the general rehabilitation of people with stroke. Only literature from within the last 10 years (2014-2024) was included. Key search terms used across all databases included stroke, visual deficit, technology, virtual reality, and lower vision devices. For inclusion, the article must include adults with stroke and visual deficits and assess the effectiveness of a technology-based intervention. Articles that use technology as an outcome measure rather than an intervention were excluded from this review. Articles were excluded if they were meta-analyses, systematic or scoping reviews, book chapters, or conference presentations.

Literature screening procedure

The literature screening process consisted of two phases: the title and abstract screening and the full-text screening. During the title and abstract screening, each record was reviewed by two authors independently. Discord between the two authors was resolved by discussing with each other, consulting with the other authors, or requesting a full-text review. Records that passed the initial screening and needed more information to determine eligibility were moved onto the full-text screening. The full-text screening process was similar to the title and abstract screening. Reasons for exclusion at this phase were recorded. The software COVidence was used during the literature screening phases.

Data extraction, methodology, rating, and synthesis

Article information is extracted in standard form. One author extracted the data, and another author checked the data. The findings of the final included articles were synthesized based on the intervention.

RESULTS

The final synthesis included ten studies. Key findings were reported based on three intervention themes. The first theme includes intervention modality, including two subthemes: computer-based intervention of a more standard treatment approach traditionally provided in the clinic [7-10]. And more innovative and individualized treatment technology [11-16]. The second theme was the treatment dosage, with five high dosages [7, 12, 14, 15, 16] and five low-dosage interventions [8-11, 13]. The last theme was the location of the intervention, with eight studies taking place in the clinic [7-13, 16] and two studies having intervention settings in the home [14,15].

Two Level II randomized controlled trials [7, 8] and two Level III quasi-experimental designs [9, 10] examined the effectiveness of the computer-based intervention. Both Level II articles found significant improvement in visual recovery. Kim et al. found significant improvement in visuospatial perception, visual field, attention, and visual memory over the course of the treatment compared to a population receiving older, traditional treatment methods [7]. Murray et al. found a reduction in symptoms of saccades [8]. Regarding the Level III research designs, one showed a significant improvement in the neuroplasticity of residual brain structures over the span of the treatment duration [10]. The other study demonstrated no significant changes in visual search time when comparing the treatment and control groups [9].

Six studies assessed the effectiveness of higher-tech, individualized, and computer-assisted technology such as virtual reality (VR) and video games. All three studies demonstrated positive results with improved visual field, visual acuity, contrast sensitivity, and improved reading function [11-13]. A common VR approach to therapy involves a specific intervention approach called visual restitution therapy (VRT), an individualized and adaptive light stimulation to the border of the impaired and intact visual field [11, 14, 15]. This intervention had one level II study [11] and one level V study that showed improvement in the visual field deficit [11, 14]. However, one Level IV study demonstrated no

improvement in the visual field after the VRT intervention [15]. Two additional VR interventions were individualized and used adaptable and smart technology, one Level IV and one Level III, which utilized a video game-based approach that had positive results and showed improvement in visual neglect, neuroplasticity, and reading [13, 16].

The dosage theme examines whether high dosage with high repetitions had different effects than low dosage with fewer repetitions. Five studies had high-dosage interventions. Of these five studies, there was one Level II study [7], one Level III [12], two Level IV studies [15, 16], and one Level V study [14]. Five studies had low-dosage interventions. Of these five studies, there was one Level II study [8] and four Level III studies [9, 10, 11, 13]. One level IV study considered high dosage, with the intervention lasting five months, six days a week with two thirty-minute daily sessions, reported a placebo effect of increased subjective visual function but did not demonstrate an improved effect [15]. A Level III study also showed visual field improvement with a lower dosage of only ten sessions for twenty minutes daily [11]. All articles had positive outcomes, including improved visual field deficits, visuospatial perception, peripheral and central acuity, reduced symptoms of saccades, and improved visual neglect. Since both high-dosage and low-dosage interventions had similar outcomes, having a higher dosage does not seem to affect the results. Additionally, since the studies with a lower dosage of interventions have higher levels of evidence with both two and three, this supports the idea that a higher dosage for interventions is unnecessary to have an effective and positive outcome.

The theme of clinical intervention versus home-based intervention was determined after eight of the ten studies took place in the clinic. All eight studies improved the visual field, central and peripheral acuity, visuospatial attention, visual scanning, visual neglect, and symptoms of saccades [7-13, 16]. Of these eight studies, two are Level II studies [7, 8], five are Level III studies [9-13], and one is Level IV studies [16]. Interestingly, Sahaire et al. demonstrated their intervention in the clinic but discussed that their tool could be used in the home [9]. With this, it was noted that while their results demonstrated an improvement in visual search time in the intervention group, there was also an increase in the control group. Thus, it is unclear how the home versus clinic environment plays a role in these results [9]. Two studies took place in the home environment; of these two, one is a Level IV study [15], and one is a Level V study [14]. Although there was a decrease in visual field deficits, the overall results were neutral in terms of improved visual functioning [14]. Results from Leitner et al. demonstrate that their intervention in the home environment showed no change in visual field deficits [15].

DISCUSSIONS

Treatment delivery was divided into two forms of intervention: lower technology and higher technology. The lower technology (represented by subtheme one) significantly improves visual symptoms and functional outcomes. The higher technology (represented by subtheme two) demonstrated that the intervention could produce neuroplastic change and functional improvement, but several articles demonstrated no change. The conclusion that can be drawn from this is that less innovative, traditional, and lower-cost technology-based approaches can produce similar, if not improved, visual recovery outcomes. When examining the intervention dosages, five studies had high-dosage interventions, and five studies had low-dosage interventions. While these studies differed in the intervention dosages, they all positively impacted visual symptoms, showing that a high dosage is not necessarily better than a lower dosage. Additionally, studies with lower intervention dosages had a higher score in relation to the level of evidence that should be considered when deciding dosage. Therefore, it should be recommended that when treating individuals for low vision deficits, a lower dosage intervention can be utilized. Additionally, treatment was either administered in a clinic setting or the home environment. All eight articles in the clinical setting demonstrated a positive impact on visual recovery or functional impact of vision. At the same time, the two home environment studies had neutral information on whether the intervention proved to be beneficial. Based on these findings, it is recommended that therapists treating individuals with low vision deficits complete their interventions in the clinic rather than at home for the best patient outcomes.

A limitation of this rapid systematic review is that this study only contains results from 10 studies. In addition, only two articles were randomized controlled trials (level ii). Low vision rehabilitation is still a relatively emerging area of practice, the role of technology should be further explored in future research.

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