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Review Article

Effectiveness of Optokinetic Stimulation as a Therapeutic Intervention for Unilateral Neglect: A Systematic Review

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Background: Unilateral Spatial Neglect (USN) is a common neuropsychological condition often resulting from brain injury, leading to a lack of attention to one side of space. Optokinetic Stimulation (OKS) has emerged as a promising intervention for reducing USN symptoms, leveraging dynamic visual stimuli to facilitate sensory reorganization and attentional shift. **Methodology:** This literature review synthesizes findings from 10 studies (2005–2024) investigating the efficacy of Optokinetic Stimulation for USN. The studies selected include randomized controlled trials and clinical investigations evaluating the impact of OKS on spatial attention and neurophysiological changes in patients with USN. **Results:** Optokinetic Stimulation was found to produce significant improvements in visuospatial tasks such as line bisection and cancellation, with effects maintained at follow-up. Studies indicated that OKS enhances attention by engaging smooth pursuit eye movements and activating parieto-occipital networks, promoting interhemispheric balance. Short-duration interventions also yielded positive results, supporting the clinical feasibility of OKS as an effective, time-efficient treatment. **Conclusion:** OKS offers a promising therapeutic approach for USN, providing both immediate and sustained benefits in spatial attention and functional outcomes. Future research should further explore its mechanistic basis and optimal treatment protocols.

Keywords: Unilateral Spatial Neglect, Optokinetic Stimulation, Attentional Shift, Neuroplasticity, Post-stroke Rehabilitation.

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Introduction

Unilateral neglect, also known as hemispatial neglect, is a disabling neuropsychological condition commonly observed in patients with right hemisphere stroke or brain injury, leading to deficits in spatial awareness and attention on the contralesional side (Heilman et al., 2003).[1] It is most commonly associated with lesions in the right hemisphere, leading to deficits in perceiving and interacting with

stimuli on the left side of space.[1] Patients with unilateral neglect may fail to attend to objects, people, or even their own body parts on the affected side, significantly impairing their ability to perform daily activities.[1] This condition not only affects functional independence but also increases the risk of falls and injuries, making it a critical concern in neurorehabilitation.[2]

Optokinetic stimulation (OKS) has emerged as a promising non-invasive therapeutic intervention aimed at restoring spatial attention by utilizing moving visual stimuli to encourage attentional shifts toward the neglected space (Kerkhoff, 2000).[3] OKS involves the presentation of moving visual stimuli, such as moving stripes or dot patterns, which elicit optokinetic nystagmus a reflexive eye movement in response to continuous motion.[3] This stimulation is thought to engage neural pathways involved in visual processing and spatial attention, potentially helping to recalibrate the disrupted spatial perception seen in unilateral neglect.[3] The mechanism of OKS is based on its ability to activate both cortical and subcortical structures responsible for attention and orientation, thereby improving the patient's ability to detect and respond to stimuli on the neglected side.[3]

Despite its potential, the effectiveness of OKS as a rehabilitation tool for unilateral neglect remains an area of active research.[4] Various factors, including the severity of neglect, lesion location, and the duration of intervention, may influence treatment outcomes.[4] Additionally, the integration of OKS with other rehabilitation approaches, such as prism adaptation, transcranial stimulation, and conventional occupational therapy, is being explored to enhance its efficacy.[5] Understanding the mechanisms by which OKS influences spatial processing and attentional networks is essential for developing standardized treatment protocols that maximize patient recovery.[5]

The purpose of this literature review is to critically examine the existing research on the effectiveness of optokinetic stimulation as a therapeutic intervention for unilateral neglect. By analyzing current evidence, this review aims to provide insights into the efficacy, limitations, and potential future directions of OKS in clinical practice. Given the impact of unilateral neglect on patient outcomes, it is crucial to explore innovative, evidence-based interventions that can improve functional independence and quality of life. Through this review, we seek to bridge gaps in knowledge, highlight emerging trends, and contribute to the ongoing advancement of neurorehabilitation strategies.

Objective of the study

This literature review will systematically examine the existing evidence regarding the effectiveness of optokinetic stimulation as a therapeutic intervention in patients with unilateral neglect.

Materials and methods

Study Design

This review of literature is based on the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) guidelines to ensure the transparency and rigor in study selection and data extraction.

Inclusion Criteria

- This study will include randomized controlled trial, pilot studies, case control studies, clinical trials publications.
- Studies that specifically investigate the use of optokinetic stimulation as a therapeutic approach.
- The study will include full-text articles, rather than abstracts or summaries.
- Both sexes are encompassed.
- Articles released from 2005 to 2024 will be included.
- Only articles published in English will be taken into account.

Exclusion Criteria

- Articles published in languages other than the regional language were omitted.
- Articles such as narrative reviews, literature reviews, systematic reviews, and meta-analyses were not included.
- Publications released before 2005 were also excluded.
- Studies focusing on other visual or spatial interventions (e.g. prism adaptation, transcranial stimulation) without mention of OKS.
- Studies those are not relevant to the specified keywords.

Methodology

The evidence was gathered from online web publications obtained from different search engines, including Google Scholar, PubMed, Scopus and other journals. A tailored search was conducted using key words such as "unilateral neglect", "hemispatial neglect rehabilitation", "optokinetic stimulation", and "visual motion therapy in neglect" to retrieve relevant

publications. Boolean operators (AND, OR) were applied to refine search results. The time period was designated as 2005 to 2024 in order to gather precise and current facts. We have identified a total of 10 articles that meet our specific criteria for inclusion and exclusion. All 10 publications were obtained in their entirety to be analysed and continued with further analysis. The results are derived using a systematic approach from all articles and displayed in a tabular format for enhanced comprehension. No meta-analysis was conducted due to variability in study designs, interventions, and outcome measures. The selection techniques are detailed in the PRISMA Chart depicted in Fig.1.

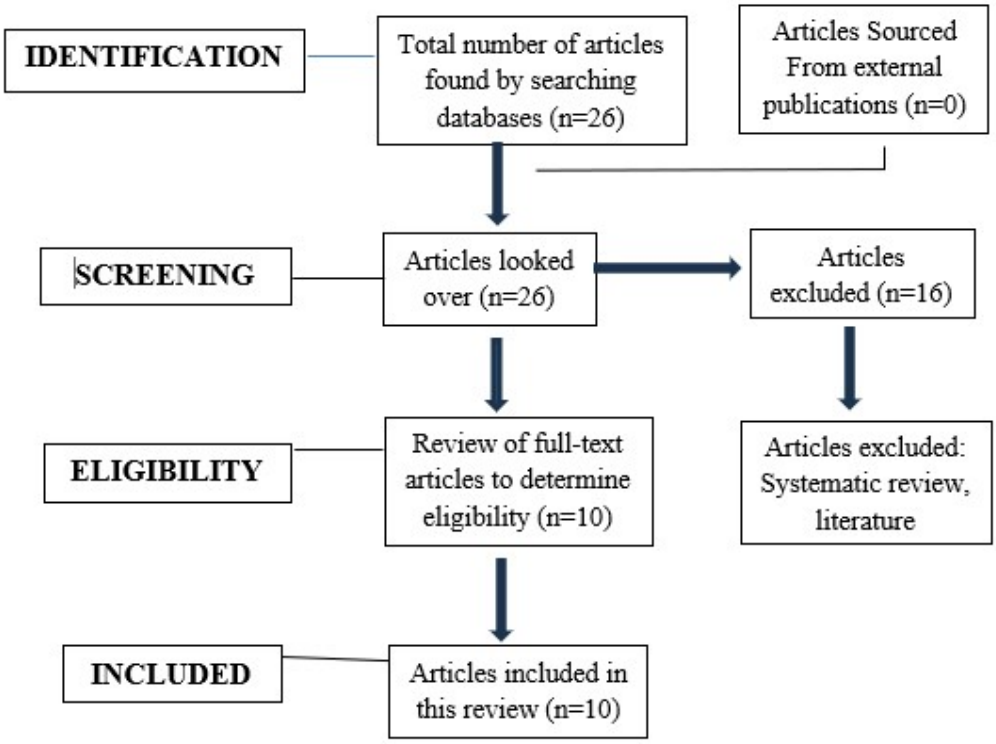

Fig 1: Prisma chart for inclusion review.

Review of literature: The characteristics of extracted article have been listed in Table 1

Table 1: Characteristics of extracted articles

Sr. No.	Author	Year	Significant Findings
1.	G. Kerkhoff, et.al.	2006	The findings indicated that the OKS (optokinetic stimulation) treatment produced significantly better outcomes in all five patients, with these effects being consistent across all tasks performed and maintained during follow-up assessments. Conversely, VST (visual scanning training) did not yield notable improvements in any of the tasks, with the exception of line bisection. The study concluded that utilizing moving visual stimuli alongside active smooth pursuit eye movements may be more effective than traditional visual scanning training that relies on static visual displays.
2.	Moon SY, et.al.	2006	Optokinetic stimulation (OKS) with a leftward slow component has shown potential in temporarily alleviating hemi-spatial

			neglect, likely through reactivation of a distributed multisensory vestibular network. While left cold caloric stimulation also improves neglect by preferentially activating the right hemisphere, its effects are bilateral and less direction-specific. In contrast, OKS offers a more targeted, direction-specific stimulation, making it a potentially superior approach for rehabilitation. However, the exact neural mechanisms and hemispheric activation patterns of OKS remain inconsistent in functional imaging studies, necessitating further research to optimize its clinical application.
3.	Ingo Keller, et.al.	2009	This study found that Optokinetic Stimulation with Pursuit (OKSP) produced significant short-term therapeutic effects on visuospatial neglect within just 30 minutes, with improvements generalizing across multiple visual and tactile tasks. OKSP was shown to be more effective than traditional visual scanning training, and the improvements were stable over a 2-week follow-up. The study also highlighted the underlying mechanisms, suggesting OKSP facilitates attention toward the neglected side and may activate both damaged and undamaged brain regions. However, prism adaptation showed no additional benefit, and movements of the ipsilesional arm during therapy worsened neglect symptoms, likely due to divided attention or misdirected visuospatial focus. While long-term effects remain uncertain, the findings support OKSP as a promising bottom-up approach that may outperform top-down strategies like scanning training, especially when applied in structured and sequential interventions.
4.	Konstantinos Priftis, et.al.	2012	The findings suggest that OKS-induced visuospatial attention shifts directly impact number interval bisection performance, reinforcing the role of spatial neglect in MNL distortions. This highlights OKS as a potential therapeutic tool for addressing both physical and cognitive aspects of neglect.
5.	Roberta Daini, et.al.	2013	Optokinetic stimulation (OKS) shows differential effects on neglect dyslexia (ND) errors, improving omissions but not substitution errors. This study emphasizes that OKS can be selectively beneficial, particularly for omission-type errors. It highlights the potential of OKS in targeted interventions for reading deficits in neglect patients.
6.	Björn Machner, et.al.	2014	This randomized controlled trial found that early combined intervention of Hemifield eye patching (HEP) and Optokinetic Stimulation (OKS) did not provide additional therapeutic benefits beyond the spontaneous remission of spatial neglect in acute stroke patients. However, this does not imply a failure of OKS as a therapeutic tool. OKS has shown beneficial effects in chronic neglect patients, and its role in enhancing visuospatial attention and perceptual realignment makes it a promising intervention. The strong spontaneous recovery in the control group may have masked the intervention's effects in the acute stage, suggesting that OKS could still be more effective in later

			rehabilitation phases. Given the absence of a proven neglect-specific intervention for the acute stage, a structured approach integrating OKS at optimal time points may still offer advantages in long-term recovery.
7.	Jong Hun Kim, et.al.	2015	Study showed that the OKS delivered by a see through (Head mounted display) HMD can be a potential treatment strategy for hemi-spatial neglect and the development of a portable device may aid in the treatment of neglect.
8.	Alessio Facchin, et.al.	2021	Both optokinetic stimulation (OKS) and prism adaptation (PA) are effective techniques for improving spatial neglect symptoms in the post-acute phase. Their comparable efficacy suggests that either method can be integrated into clinical practice, with the choice depending on individual patient needs and specific rehabilitation goals. Given OKS's role in enhancing visuospatial attention through dynamic sensory input, it remains a valuable tool for targeted intervention in neglect therapy.
9.	Fátima Pérez Robledo, et.al.	2023	This study underscores the effectiveness of optokinetic stimulation (OKS) as a comprehensive rehabilitation tool for patients with unilateral spatial neglect (USN), addressing both perceptual and postural deficits. The use of virtual reality-based OKS further improves outcomes by providing a more precise correction compared to traditional screen-based applications. OKS stands out as an effective and accessible intervention, offering a valuable addition to USN rehabilitation strategies.
10.	Lisa Kunkel genannt Bode, et.al.	2023	Although this study did not find a clinically significant effect of the combined intervention on neglect symptoms post-stroke, it does not undermine the potential benefits of optokinetic stimulation (OKS) as a standalone treatment. While the combination of OKS with instructor-assisted reading did not lead to substantial functional improvements beyond spontaneous remission, the mild attenuation of ipsilesional attention bias suggests that OKS may still have a role in modulating visuospatial deficits. The study highlights the importance of treatment intensity and the need for further research to optimize OKS protocols for greater therapeutic efficacy. Given the existing evidence supporting OKS in improving spatial attention and postural control, it remains a promising intervention that warrants further exploration in different clinical settings.

Discussions

The primary aim of this literature review was to gather and categorize papers focused on treating unilateral neglect through the use of optokinetic stimulation and find out the effectiveness of this intervention for lowering unilateral neglect symptoms. We have found 26 articles that correspond to our keywords in a variety of reputable journals. These studies provide valuable insights into the potential benefits, limitations, and recent advancements in OKS for patients with USN. After carefully examining the inclusion and exclusion criteria, we were able to gather 10 articles in the form of randomized controlled trials (RCTs), pilot studies, clinical trials from the years 2005 to 2024. These articles will be further analysed.

The study by Kerkhoff et al. (2006) found that repetitive optokinetic stimulation (OKS) has significant therapeutic effects across various visual neglect tasks, demonstrating improvements that extend across multiple domains, different tasks, and input/output modes, such as line bisection.[6] Moreover, OKS was shown to be more effective than conventional visual scanning training. Additionally, the study revealed that OKS provides therapeutic benefits comparable to other innovative rehabilitation techniques, including attentional and limb activation training, neck muscle vibration, and prism adaptation.[6]

Moon SY, et.al. 2006, from their study said that Lateralized sensory stimulation, such as left cold caloric stimulation and leftward optokinetic stimulation (OKS), can temporarily improve hemispatial neglect.[7] OKS, however, has shown greater therapeutic potential as it not only reactivates a multisensory vestibular network in the lesioned hemisphere but also provides broader and longer-lasting improvements across various neglect tasks.[7] OKS engages both hemispheres and has been found to be more effective than conventional visual scanning training.[7]

Ingo keller, et al. (2009) demonstrated that Optokinetic Stimulation with Pursuit (OKSP) significantly improves visuospatial neglect within 30 minutes, with effects transferring across tasks and lasting up to two weeks.[8] OKSP outperformed visual scanning training, but prism adaptation showed no added benefit, and ipsilesional arm movements worsened symptoms. The study supports OKSP as an effective short-term, bottom-up therapy for neglect.[8]

In 2012, konstantinos Priftis et al. demonstrated that optokinetic stimulation (OKS) effectively reduced spatial bias and response variability in a left neglect patient, showing that shifting visuospatial attention with OKS improves both physical and mental space processing.[9]

In 2013, Roberta Daini, et al. studied the effects of optokinetic stimulation (OKS) on two patients with different types of neglect dyslexia (ND).[10] Only the patient with omission-type ND and oculomotor impairment showed improvement after OKS. This suggests that OKS may be specifically effective for omission errors linked to visual exploration deficits, supporting a targeted approach to ND rehabilitation.[10]

Björn Machner, et.al. in 2014 from their randomized controlled trial found that combining Hemifield Eye Patching (HEP) and Optokinetic Stimulation (OKS) in acute stroke patients did not show added benefit over spontaneous recovery.[11] However, OKS remains promising, especially for chronic neglect, due to its role in enhancing visuospatial attention. The strong natural recovery in the acute phase may have masked OKS effects, suggesting it could be more effective in later rehabilitation stages with timely, structured application.[11]

In 2015, Kim et al. demonstrated that while traditional screen-based optokinetic stimulation (OKS) effectively reduces hemispatial neglect, it can lead to overcorrection, causing neglect of the right hemispace.[12] Their study introduced the novel use of see-through head-mounted displays (HMDs) for OKS delivery, which allowed patients to perceive real-world objects while receiving stimulation. The HMD-based OKS produced more balanced corrections with less distraction, suggesting it may be a more practical and tolerable therapeutic tool.[12]

In 2021, Alessio Facchin et al. compared the effectiveness of prism adaptation (PA) and optokinetic stimulation (OKS) in post-stroke neglect patients using a crossover design.[13] Both interventions showed similar improvements in neglect symptoms over multiple sessions, suggesting equivalent efficacy. While no significant difference was found between the two methods, both appeared to activate overlapping neural regions involved in visuospatial attention. The study highlights that either technique can be effectively used in clinical settings based on patient needs.[13]

In 2023, the study by Lisa et al. conducted a randomized controlled crossover trial to evaluate the effectiveness of optokinetic stimulation (OKS) combined with reading therapy (READ) in patients with right hemispheric stroke and neglect.[14] The study found that while OKSREAD led to a slight 6% improvement in overall neglect test performance. These findings underscored the potential of OKS to reduce ipsilesional attentional bias in patients with neglect.[14]

In 2023, the study by Fátima Pérez Robledo et al. highlighted the strengths of establishing a standardized optokinetic stimulation (OKS) protocol to assess its impact on both perceptual and postural symptoms in unilateral spatial neglect (USN) patients.[15] By applying OKS in a standing position using virtual reality glasses, the study aimed to enhance patient immersion and treatment effectiveness.[15] Key parameters like stimulus speed, direction, and attention were controlled to improve outcomes. While the study's randomized design and sample size support generalizability, limitations include a narrowly tested speed and short intervention

period. Overall, OKS was shown to be a practical, cost-effective tool that could innovate physiotherapy approaches for USN.[15]

The findings from the reviewed literature suggest that OKS can significantly enhance visuospatial attention and perceptual realignment in individuals with neglect.[6] Studies have demonstrated its superiority over traditional visual scanning training (VST) and its ability to induce sustained improvements.[6] Furthermore, OKS has been explored as an alternative to other interventions, such as prism adaptation, with comparable effectiveness in post-acute rehabilitation.[13] The reviewed articles highlight the role of OKS in reactivating multisensory vestibular networks, reinforcing the notion that dynamic visual stimulation contributes to neuroplastic changes essential for recovery.[7]

Recent advancements in technology have further enhanced the potential of OKS as a rehabilitation tool. The development of head-mounted displays (HMDs) and virtual reality-based OKS has introduced more precise and accessible treatment options, allowing for greater flexibility in therapy delivery.[12] These innovations provide immersive and engaging environments that can improve patient adherence and outcomes. However, some studies indicate that the effectiveness of OKS may vary depending on treatment intensity and the specific combination with other interventions, necessitating further research to optimize rehabilitation protocols.

Conclusion

This review highlights the effectiveness of Optokinetic Stimulation (OKS) as a therapeutic intervention for unilateral neglect. Across studies, OKS consistently improved visuospatial attention and performance in both visual and cognitive tasks. It outperformed traditional visual scanning training and showed comparable or superior results to interventions like prism adaptation. OKS also demonstrated lasting benefits, especially when applied in structured, repeated sessions. Technological advancements like VR and head-mounted displays have enhanced OKS delivery, making it more accessible and engaging. OKS was effective in both acute and chronic phases, though results varied with timing and intensity. It activates multisensory and vestibular networks, promoting neuroplasticity. Some studies showed limited effects due to spontaneous recovery, but overall, evidence supports OKS's role in targeted rehabilitation. OKS is a promising, non-invasive, and cost-effective approach for improving spatial attention and functional recovery in patients with unilateral neglect.

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