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"A Review of Knowledge, Awareness, and Practice Among Eye Care Professionals Towards Convergence Insufficiency: Prevalence, Diagnosis, and Treatment Innovations in young adults."

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Abstract:

This review investigates convergence insufficiency (CI), a prevalent non-strabismic binocular vision disorder, in young adults aged 18–35 years. CI disrupts near vision tasks, leading to symptoms like eye strain, headaches, and difficulty concentrating, significantly affecting productivity and quality of life in today's digital age. While global CI prevalence averages 7.98%, it is markedly higher in India at 37.2%, particularly among students. Despite its impact, clinical management remains inconsistent due to variability in diagnostic criteria and treatment outcomes. A systematic review of 45 studies published between 1999 and 2023 (one from 1983) identified 25 that met inclusion criteria, emphasizing diagnostic techniques, therapeutic strategies, and the practices of optometrists and ophthalmologists. Findings reveal a research focus on children, with limited data on young adults, and highlight variability in knowledge, attitudes, and practices (KAP) among eye care professionals. Key gaps include the need for robust data on CI prevalence using vergence and accommodative assessments, standardized evaluation of professional KAP through structured tools, and exploration of remote diagnosis and treatment options via software-based solutions. Additionally, comparing traditional therapies like the Brock String with modern methods such as VR-based interventions could refine management strategies. Addressing these gaps is essential for improving CI diagnosis, treatment, and outcomes in young adults.

Keywords: *Convergence, Binocular Vision, Vision Therapy*

1. Introduction

Convergence Insufficiency is a common binocular vision disorder characterized by an inability to maintain proper eye alignment during near work, often leading to symptoms such as eye strain,

headaches, and difficulty concentrating. This research aims to investigate the prevalence of CI among young adults and assess the knowledge, attitudes, and practices of eye care professionals regarding its diagnosis and treatment.

This study is a systematic review of studies from 1999 to 2023 (except one study of 1983) was conducted using PubMed, Google Scholar, and the Cochrane Library, focusing on CI prevalence, diagnosis, and management in young adults. Out of many identified studies, 37 met inclusion criteria, emphasizing diagnostic methods, therapeutic approaches, and eye care professionals' practices for CI.

This study explores current diagnostic approaches for CI. Additionally, this research evaluates emerging technologies in the treatment of CI, focusing on advancements that enhance patient outcomes, such as virtual reality and digital therapeutic exercises. By examining the KAP framework among professionals, this study seeks to identify gaps in awareness and identify the barriers in CI management, contributing to valuable insights to the field of binocular vision.

2. Review

2.1 Global Prevalence of Convergence Insufficiency:

Zoelfigar Mohamed, Saif Hassan Alrasheed et al conducted a systematic review and meta-analysis assessed the prevalence of convergence insufficiency and treatment options, finding a pooled prevalence of 7.98% across the reviewed studies, with significant heterogeneity among them. The review included 35 peer-reviewed studies published between January 2000 and January 2023, which were screened from an initial pool of 13,250 studies (Mohamed & Alrasheed, 2023).
Pillay & Munsamy did a literature review which indicates that the prevalence of convergence insufficiency among younger populations varies significantly, with non-clinical studies reporting rates between 5.46% to 13.00% and clinical studies showing rates from 3.50% to 18.00%. Specifically, CI prevalence among primary school children ranges from 6.80% to 31.40%, while high school children may experience rates as high as 32.60%, (Pillay & Munsamy, 2021).

2.2 Prevalence of Convergence Insufficiency in India:

Convergence Insufficiency is consistently reported as the most prevalent Non Strabismic Binocular Vision Anomaly across various studies, affecting a significant portion of the population studied (Shongmu & Akhtar, 2024) (Hussaindeen et al., 2017).
A study among university students in North India found a high prevalence of NSBVA at 62.2%, with convergence insufficiency being the most common anomaly at 37.2% (Shongmu & Akhtar, 2024).
Hussaindeen et al conducted a Population-based, cross-sectional study on 920 children aged 7 to 17 years found the prevalence of non-strabismic anomalies of binocular vision among school children in Tamil Nadu, India, was found to be 31.5% in urban areas and 29.6% in rural areas, with convergence insufficiency being the most prevalent anomaly with 16.5% urban, 17.6% rural population suffering from it (Hussaindeen et al., 2017).

2.3 Impact of Convergence Insufficiency on Clinical and Quality of Life Impact:

Convergence insufficiency significantly impacts patients' visual performance and quality of life, particularly during tasks requiring close visual work. This condition is characterized by symptoms

such as eye strain, blurred vision, double vision, headaches, and difficulty reading, which can lead to discomfort and reduced functional capacity in daily activities. The impact of CI extends beyond physical symptoms, affecting psychosocial aspects and overall quality of life.

CI is associated with impaired visual performance, leading to difficulties in tasks such as reading and other near work activities. This is reflected in worse scores on the Convergence Insufficiency Symptom Survey (CISS) and Adult Strabismus-20 (AS20) quality-of-life questionnaire, which correlate with reading function and overall quality of life (Jong et al., 2023) (Lorenzana et al., 2022). Interventions such as orthoptic exercises and prisms have shown improvements in near-point of convergence (NPC) and quality-of-life scores, indicating that treatment can alleviate symptoms and enhance life quality (Jong et al., 2023). Despite these improvements, long-term compliance with treatment remains a challenge, highlighting the need for patient education and support (Jong et al., 2023).

2.4 Diagnosis of convergence insufficiency

Diagnosing convergence insufficiency involves a combination of clinical tests and symptom surveys to accurately identify this binocular vision disorder. CI is characterized by difficulty in maintaining proper eye alignment for near tasks, often leading to symptoms such as eyestrain, headaches, and blurred vision. The diagnostic process typically includes evaluating the near point of convergence, fusional vergence amplitudes, and symptom surveys like the Convergence Insufficiency Symptom Survey. Each diagnostic tool has its strengths and limitations, necessitating a comprehensive approach for accurate diagnosis.

Diagnostic Questionnaires

- **Convergence Insufficiency Symptom Survey:** The CISS is a widely used tool for diagnosing CI, with a sensitivity of 62.9% and specificity of 96.8% in some studies. However, its sensitivity is relatively low, suggesting it should be supplemented with other tests for a more accurate diagnosis (Xiong & Wu, 2024) (Lavrich et al., 2023).
- **College of Optometrists Vision Development Quality of Life Questionnaire (COVD-QOL):** Shows a higher sensitivity of 71.0% but lower specificity (Xiong & Wu, 2024).

Xiong & Wu, 2024 found in their study that combination of the CISS and COVD-QOL resulted in lower sensitivity and specificity compared to the CISS alone, suggesting that neither questionnaire is sufficient on its own for effective screening. Therefore, it is recommended to supplement these questionnaires with other screening tests for more accurate detection of convergence insufficiency.

Clinical Tests

- **Near-Point of Convergence:** Measurement of NPC, especially using a red lens, is one of the most sensitive tests for diagnosing CI, with a sensitivity of 93.3% (Lavrich et al., 2023). A receded NPC is a common sign of CI, often used in conjunction with other tests to confirm the diagnosis (Sahu & Agrawal, 2022).

- **Fusional Vergence Amplitudes:** Decreased positive fusional convergence (PFC) at near is another key indicator of CI. The sensitivity of this test is lower than NPC, but it remains an important component of the diagnostic process (Lavrich et al., 2023) (Lederer & Poltavski, 2015).
- **Sheard's and Percival's Criteria:** These criteria are used to evaluate vergence facility and have shown high diagnostic performance in distinguishing CI from other binocular vision anomalies(Moon et al., 2020).
- **Quality of Convergence Movement (QoCM) and Quality of Fusional Movements (QoFM):** Subjective assessments of these movements have demonstrated high sensitivity (98.4% and 94.5%, respectively) for diagnosing CI (Lavrich et al., 2023).

While the above methods provide a robust framework for diagnosing CI, it is important to consider the variability in diagnostic criteria and the potential for misdiagnosis. The presence of CI can significantly impact quality of life, emphasizing the need for accurate and comprehensive diagnostic approaches.

2.5 Implications of Convergence Insufficiency on Clinical Practice:

The management of CI in clinical settings is complicated by inconsistent diagnostic criteria and variable treatment outcomes. This necessitates a comprehensive understanding of its implications for effective diagnosis and management strategies.

- **Diagnostic Challenges:** CI diagnosis is often inconsistent due to varying criteria and methodologies across studies and clinical practices. This inconsistency can lead to misdiagnosis or inclusion of other conditions under CI, highlighting the need for standardized diagnostic criteria and procedures (Lavrich et al., 2019) (Gantz, 2022). The variability in diagnostic signs, such as near point of convergence and fusional amplitudes, further complicates the clinical evaluation of CI (Lavrich et al., 2019) (Gantz, 2022).
- **Treatment and Management:** Treatment options for CI include vision therapy, orthoptic exercises, and the use of prisms. These interventions have shown improvements in symptoms and quality of life, as evidenced by increased Adult Strabismus-20 (AS20) scores and improved NPC measurements (Lorenzana et al., 2022) (Jong et al., 2023). Long-term compliance with treatment remains a challenge, with higher dropout rates observed in exercise-based interventions compared to prism use (Jong et al., 2023).
- **Population-Specific Considerations:** The prevalence of CI is notably high in the geriatric population, necessitating special attention to this age group in clinical practice. Despite the high prevalence, there is no significant trend with age, indicating that CI affects older adults consistently across different age brackets (Hashemi et al., 2021).

2.5 Treatment Approaches for Convergence Insufficiency:

Various non-surgical therapies have been explored to address CI, with differing levels of effectiveness. The most effective treatment appears to be office-based vision therapy, which has shown superior outcomes compared to home-based methods. Below are the key therapies for CI and their effectiveness based on the available research.

Prism Glasses

- Prism lenses have been explored as a potential alternative to vision therapy for treating convergence insufficiency in adults, but their effectiveness remains debated. While some studies suggest that prism lenses can reduce symptoms, they may not address the underlying issues as effectively as vision therapy.
- Base-in prism glasses have been explored as a treatment option, but evidence suggests they are not more effective than placebo glasses in children. However, in adults, prism glasses with a progressive addition lens design showed some effectiveness in reducing symptoms (Scheiman et al., 2011).
- In young adults, the effectiveness of prism therapy was linked to baseline clinical characteristics. A higher baseline symptom score and a remote NPC were associated with increased prism effectiveness. However, the prism adaptation rate was the only independent predictor, with effectiveness increasing as adaptation rate decreased (Hashemi et al., 2021).

Office-Based Vision Therapy (OBVT)

- OBVT has been shown to be the most effective treatment for CI, particularly in children. In a randomized clinical trial, OBVT resulted in a significantly lower Convergence Insufficiency Symptom Survey score and improved near point of convergence and positive fusional vergence (PFV) compared to other treatments (Scheiman et al., 2008).

- Another study confirmed that OBVT was more effective than home-based exercises, with significant improvements in NPC, PFV, and CISS scores in children (Scheiman et al., 2011).

Home-Based Therapies

- Home-based pencil push-ups (HBPP) and home-based computer vision therapy (HBCVAT+) are common initial treatments but are generally less effective than OBVT. HBPP showed a 43% success rate, while HBCVAT+ had a 33% success rate in improving CI symptoms (Scheiman et al., 2008).

- In adults, home therapy alone was less effective, with a success rate of 30%, compared to 61.9% for those receiving both office and home therapy (Birnbaum et al., 1999).

Fusional Vergence Training

Fusional vergence training is a therapeutic approach used to address convergence insufficiency; a common binocular vision disorder characterized by difficulties in maintaining eye alignment for near tasks. This training aims to improve the coordination of eye movements, specifically enhancing the positive fusional vergence and near point of convergence. Various studies have explored different methods and their effectiveness in treating CI, providing insights into the benefits and limitations of fusional vergence training.

Effectiveness of Fusional Vergence Training

- **Automatic Dual Rotational Risley Prisms (ADRRPs):** A study using ADRRPs demonstrated significant improvements in vergence abilities among young adults. Participants showed enhanced NPC and PFV after 12 weeks of training, with CI symptom scores decreasing significantly. This suggests that ADRRPs can be an effective tool for improving vergence in individuals with CI (Chen et al., 2024).
- **Vergence/Accommodative Therapy:** The Convergence Insufficiency Treatment Trial-Attention and Reading Trial (CITT-ART) found that office-based vergence/accommodative therapy led to sustained improvements in NPC and PFV in children with CI, even one-year post-treatment. This indicates the long-term benefits of such therapy in maintaining improved convergence function (Morrison et al., 2024).
- **Vergence vs. Accommodation Exercises:** A study comparing vergence and accommodation exercises in school children found that vergence exercises led to faster recovery from CI. This suggests that focusing on vergence exercises may enhance treatment compliance and success rates (Maagaard et al., 2021).
- Automated fusional vergence training has been effective in reducing asthenopia and improving vergence ranges in patients with CI, indicating its potential as a supplementary therapy (Cooper et al., 1983).

Virtual Reality-Based Vision Therapy

- Virtual reality (VR) therapy has been shown to significantly improve binocular vision functions and symptoms in young adults with CI. It offers an effective alternative to traditional office-based vergence/accommodative therapy, with improvements noted in convergence insufficiency symptom scores and visual functions after 12 weeks of treatment (Li et al., 2022).

- VR-based vision therapy has been associated with increased compliance compared to traditional methods, as the gamification of vision training in a VR environment can make the therapy more engaging and enjoyable for patients (Boon et al., 2020).
- The immersive nature of VR allows for a controlled and safe environment where patients can practice visual tasks, potentially leading to better adherence to the treatment regimen (Зуева et al., 2024).

Home-Based Computer Orthoptic Programs

- Home-based computer orthoptic programs have demonstrated efficacy in reducing symptoms and improving near point of convergence and fusional amplitudes in children with CI. A study reported that 92% of participants became asymptomatic after using a home-based computerized vergence system therapy (Huston & Hoover, 2015) (Serna et al., 2011).

- These programs provide a flexible treatment option, allowing patients to perform exercises at their convenience, which can lead to high compliance and motivation (Carvelho et al., 2008).

- Home-based programs offer the advantage of convenience and accessibility, allowing patients to perform exercises at their own pace and in their own environment. However, adherence to home-based therapy can be inconsistent, with some studies reporting decreased adherence over time (Scheiman et al., 2020). Despite this, home-based computer programs are considered a cost-effective and less time-consuming alternative to office-based therapies (Singh et al., 2021).

Computer Gaming for Vision Therapy

- Computer games designed for vision therapy have been effective in treating CI by making the therapy more engaging and less monotonous. This approach has resulted in clinical improvements and high levels of patient compliance, as well as the ability to track progress objectively (Carvelho et al., 2008).

Combined Office-Based and Home Therapy Systems

- Combining office-based vision therapy with home therapy systems has shown superior outcomes compared to office-based therapy alone. This combined approach resulted in a higher success rate in treating children with CI, with significant improvements in symptoms and visual functions after a 12-week course (Nehad et al., 2018).

2.6 Current knowledge and awareness of Convergence insufficiency among eye care professionals

The current knowledge and awareness of convergence insufficiency among eye care professionals reveal a mixed understanding and approach to its management. CI is recognized as a common binocular vision disorder that significantly impacts quality of life, particularly affecting near activities. Despite its prevalence, there is a notable gap in consistent screening and management practices among eye care professionals.

Treatment Awareness

- Office-based vergence/accommodative therapy with home reinforcement is considered the most effective treatment, yet there is significant heterogeneity in treatment approaches (Mohamed & Alrasheed, 2023).

- Orthoptic exercises and prisms are commonly prescribed, but long-term compliance remains a challenge, highlighting the need for better patient education (Jong et al., 2023).

Challenges in Management

- There is a consensus on the importance of a comprehensive patient examination, including sensorimotor evaluation and careful refraction, before initiating therapy (Rovick, 2022).

- The lack of interprofessional collaboration and standardized treatment protocols complicates the management of CI (Rovick, 2022).

- Many eye care professionals do not routinely screen for CI, despite its impact on near vision tasks, which is increasingly relevant in the digital age (Trieu & Lavrich, 2018).

Need for Improved Education and Collaboration

- The study by Jong et al. emphasizes the importance of disease education to improve long-term treatment compliance (Jong et al., 2023).

- There is a need for increased awareness and training among eye care professionals to ensure consistent screening and management of CI (Trieu & Lavrich, 2018).

2.7 Effectiveness of remote base application of Vision therapy

- With recent development of telehealth programs, we wanted to explore the possibility of enhancing home-based vision therapy with one-on-one doctor guided and vision therapist guided remote optometric vision therapy (ROVT), which may increase access for times when the patient is not able to present to the office. Their vision therapy team of 2 doctors and 5 staff worked for 2 weeks to plan the implementation of ROVT. Telephonic informed consent was of the participants after which they were enrolled for the ROVT sessions of 25-30 minutes delivered through skype. They used a web vision therapy program developed by Shadowspawn LLC. They shared results that out of 35 patients who began ROVT most of them completed 4-8 remote sessions, and most cases have been successful. They concluded that the vast majority of patients in ROVT benefited from the program. They recommended having at least 1 office session before starting ROVT. They found office therapy to be superior to ROVT, they recommend using ROVT to supplement the office sessions. This study has several limitations like no statistical data has been shared by the author and the very limited patients and scope of the vision therapy software used.
- In another article of Cooper J. where he describes the "Use of telemedicine to implement remote diagnosis and treatment of various oculo-motor and perceptual problems". Published in Vision Dev & Rehab 2020;6(2):170-2. He used to zoom for assessment and treatment of visual dysfunction using HTS/HTS2/PTS2/PVT2 vision therapy software programs. He concluded that both diagnosis and treatment of a variety of oculomotor and perceptual problems can be done remotely. This article again has limitations of no clear methodology and no statistical data to support their claim. Hence more detailed statistical analysis is required to confirm the possibility of remote vision therapy for diagnosis and treatment of convergence insufficiency.

3. Conclusion:

This study highlights significant insights into convergence insufficiency among young adults, yet several gaps remain unaddressed that are critical for advancing clinical practice and improving patient outcomes. Despite the growing body of research, most studies disproportionately focus on children, with limited investigation into the 18–35-year-old demographic, where CI is equally impactful. The variability in diagnostic criteria and management approaches further complicates the development of standardized practices.

Key gaps identified in this review include:

1. **Prevalence Studies**: The need for more robust data on CI prevalence among young adults, using comprehensive vergence and accommodative assessment methods, remains critical to understand its true burden.

2. **Knowledge, Attitude, and Practice**: There is a lack of structured, standardized tools to evaluate the KAP among optometrists and ophthalmologists, limiting the ability to identify barriers to effective management.

3. **Technological Integration**: While emerging technologies such as VR-based therapy and remote vision therapy show promise, further research is needed to validate their efficacy compared to traditional interventions like the Brock String. The absence of consistent methodologies and statistical rigor in evaluating these solutions remains a major limitation.

4. **Remote Therapy**: The potential for telemedicine and software-based remote diagnosis and treatment is underexplored. Pilot studies suggest feasibility, but larger-scale, statistically powered investigations are necessary to establish best practices and protocols.

Addressing these gaps will require collaborative efforts from researchers, clinicians, and technologists to develop evidence-based diagnostic and therapeutic protocols. By doing so, the field can move toward more consistent, accessible, and effective management of convergence insufficiency in young adults, ultimately improving their quality of life.

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References:

1. Angela, Serna., David, L., Rogers., Mary, Lou, McGregor., Richard, P., Golden., Don, L., Bremer., Gary, L., Rogers. (2011). 4. Treatment of symptomatic convergence insufficiency with a home-based computer orthoptic exercise program. Journal of Aapos, doi: 10.1016/J.JAAPOS.2010.11.023
2. Boon, M. Y., Asper, L., Chik, P., Alagiah, P., & Ryan, M. (2020). Treatment and compliance with virtual reality and anaglyph-based training programs for convergence insufficiency. Clinical and Experimental Optometry, 103(6), 870–876.
3. Bonilla- Warford N, Kighton E. Use of remote optometric vision therapy in a primary eye care practice. Vision Dev & Rehab 2020;6(2):99-106
4. Chen, Y.-Y., Hu, Y., Huang, S.-Y., & Tsai, T. (2024). A Novel Device for Vergence Exercises: Testing Automatic Dual Rotational Risley Prisms on Asymptomatic Adults and Patients with

Convergence Insufficiency. Ophthalmology and Therapy. https://doi.org/10.1007/s40123-024-01055-1

5. Cooper J. “Use of telemedicine to implement remote diagnosis and treatment of various oculo-motor and perceptual problems”. Vision Dev & Rehab 2020;6(2):170-2
6. Gantz, L. (2022). Convergence insufficiency: Review of clinical diagnostic signs. Journal of Optometry, 15(4), 256–270. https://doi.org/10.1016/j.optom.2021.11.002
7. Hassan, Hashemi., Ebrahim, Jafarzadehpur., Payam, Nabovati., Abbasali, Yekta., Mohamadreza, Aghamirsalim., Mohammad, Kamali., Ali, Mirzajani., Mehdi, Khabazkhoob. (2021). 2. Predictor factors of prism effectiveness in young adults with convergence insufficiency. Clinical and Experimental Optometry, doi: 10.1080/08164622.2021.1878828
8. Ingryd, J., Lorenzana., David, A., Leske., Sarah, R., Hatt., Trevano, W., Dean., Erin, Jenewein., Linda, R., Dagi., Casey, J., Beal., Yi, Pang., Dashaini, V., Retnasothie., Christina, A, Esposito., S., Ayse, Erzurum., Amy, E., Aldrich., Eric, R., Crouch., Zhuokai, Li., Raymond, T., Kraker., Jonathan, M., Holmes., Susan, A., Cotter. (2022). 4. Relationships among Clinical Factors and Patient-reported Outcome Measures in Adults with Convergence Insufficiency. Optometry and Vision Science, doi: 10.1097/OPX.0000000000001929
9. Jameel, Rizwana, Hussaindeen., Jameel, Rizwana, Hussaindeen., Archayeeta, Rakshit., Archayeeta, Rakshit., Neeraj, Kumar, Singh., Neeraj, Kumar, Singh., Ronnie, George., Meenakshi, Swaminathan., Suman, Kapur., Mitchell, Scheiman., Krishna, Kumar, Ramani. (2017). 7. Prevalence of non-strabismic anomalies of binocular vision in Tamil Nadu: report 2 of BAND study. Clinical and Experimental Optometry, doi: 10.1111/CXO.12496
10. Jeffrey, Cooper., Arkady, Selenow., Kenneth, J., Ciuffreda., Jerry, Feldman., James, Faverty., Steven, C., Hokoda., Jayne, Silver. (1983). 5. Reduction of asthenopia in patients with convergence insufficiency after fusional vergence training. Optometry and Vision Science, doi: 10.1097/00006324-198312000-00007
11. Jlz, Jong., Z., Saleem., J., Simmons., M., Rhodes., JL, Choi. (2023). 1. 11 Convergence insufficiency: are we making a difference in patients' lives or is it a waste of time! BMJ open ophthalmology, doi: 10.1136/bmjophth-2023-biposa.11
12. Judith, B., Lavrich., Naomie, Warner., Alexander, J., Hauschild., Avrey, Thau., Barry, N., Wasserman., Caroline, N., DeBenedictis., Bruce, Schnall., Donelson, R., Manley., Kammi, B., Gunton., Sneha, Padidam., Jeffrey, E., Landy. (2019). 3. Inconsistent diagnostic criteria for convergence insufficiency. Journal of Aapos, doi: 10.1016/J.JAAPOS.2018.09.008
13. Koduri, M., Gella, L., Gunaganti, S., & Bhardwaj, L. R. (2021). PRACTITIONERS PERSPECTIVES ON VISION THERAPY DEVICES. International Research Journal of Modernization in Engineering Technology and Science, 03(12). https://www.irjmets.com/uploadedfiles/paper/volume_3/issue_12_december_2021/17893/final/fin_irjmets1640353048.pdf
14. Lavrich, J. B., Hamburger, J. L., Lee, K. E., Thuma, T., Omega, M. L., Zhang, Q. E., & Gunton, K. B. (2023). Creating consistency in the diagnosis of convergence insufficiency: screening methods. Journal of Aapos. https://doi.org/10.1016/j.jaapos.2023.08.019
15. Lederer, P., & Poltavski, D. (2015). Confusion Inside Panum’s Area and Symptomatic Convergence Insufficiency.

https://www.researchgate.net/profile/David_Biberdorf/publication/278678708_Article_Confusion_Inside_Panum's_Area_and_Symptomatic_Convergence_Insufficiency/links/558334a708aefa35fe30b800.pdf

16. Liat, Gantz. (2022). 5. Convergence insufficiency: Review of clinical diagnostic signs. Journal of Optometry, doi: 10.1016/j.optom.2021.11.002
17. Lisa, P, Rovick. (2022). 4. Evaluation and Management of Convergence Insufficiency in Adults. Journal of binocular vision and ocular motility, doi: 10.1080/2576117X.2022.2114307
18. Lynn, H, Trieu., Judith, B., Lavrich. (2018). 5. Current concepts in convergence insufficiency. Current Opinion in Ophthalmology, doi: 10.1097/ICU.0000000000000502
19. M, H, Birnbaum., Soden, R., A, H, Cohen. (1999). 4. Efficacy of vision therapy for convergence insufficiency in an adult male population. Journal of the American Optometric Association,
20. Maagaard, M. L., Nisted, I., & Bek, T. (2021). Vergence Exercises for Six Weeks Induce Faster Recovery of Convergence Insufficiency Than Accommodation Exercises in School Children. Investigative Ophthalmology & Visual Science, 62(6), 23. https://doi.org/10.1167/IOVS.62.6.23
21. Mitchell, Scheiman., Jane, Gwiazda., Tianjing, Li. (2011). 2. Non-surgical interventions for convergence insufficiency. Cochrane Database of Systematic Reviews, doi: 10.1002/14651858.CD006768.PUB2
22. Mitchell, Scheiman., Susan, A., Cotter., G., Lynn, Mitchell., Marjean, Taylor, Kulp., Michael, W., Rouse., Richard, W., Hertle., Maryann, Redford., Jeffrey, Cooper., Rachel, Coulter., Michael, Gallaway., David, B., Granet., K., Hopkins., Brian, G., Mohney., Susanna, M., Tamkins. (2008). 1. Randomized clinical trial of treatments for symptomatic convergence insufficiency in children. Archives of Ophthalmology, doi: 10.1001/ARCHOPHT.126.10.1336
23. Moon, B.-Y., Kim, S.-Y., & Yu, D.-S. (2020). Receiver operating characteristic curve analysis of clinical signs for screening of convergence insufficiency in young adults. PLOS ONE, 15(1). https://doi.org/10.1371/JOURNAL.PONE.0228313
24. Morrison, A., Kulp, M., Cotter, S. A., Scheiman, M. M., Jenewein, E., Roberts, T. L., Mitchell, G. L., Arnold, L. E., Retnasothi, D., Bade, A., Hertle, R., & Borsting, E. (2024). One-year follow-up of clinical convergence measures in children enrolled in the Convergence Insufficiency Treatment Trial-Attention and Reading Trial. Ophthalmic and Physiological Optics. https://doi.org/10.1111/opo.13378
25. Murali, K., Ramesh, A., Murthy, S., & Goyal, A. (2021). Binocular therapy as primary intervention in adults with anisometropic amblyopia. Taiwan J Ophthalmol.
26. Pamela, A., Huston., Darren, L., Hoover. (2015). 2. Treatment of symptomatic convergence insufficiency with home-based computerized vergence system therapy in children. Journal of Aapos, doi: 10.1016/J.JAAPOS.2015.06.004
27. Renaishia, Pillay., Alvin, J., Munsamy. (2021). 3. A review exploring convergence insufficiency in younger populations and e-devices in the digital era. African Vision and Eye Health, doi: 10.4102/AVEH.V80I1.623
28. Sahu, A., & Agrawal, D. (2022). Convergence Insufficiency as a Cause of Postoperative Acquired Diplopia after Successful Motor Alignment Post Strabismus Surgery. Journal of Binocular Vision and Ocular Motility, 72, 1–3. https://doi.org/10.1080/2576117X.2021.2002103

29. Scheiman, M., Kulp, M. T., Cotter, S. A., Lawrenson, J. G., Wang, L., & Li, T. (2020). Interventions for convergence insufficiency: a network meta-analysis. Cochrane Database of Systematic Reviews, 12(12). https://doi.org/10.1002/14651858.CD006768.PUB3
30. Shijin, Li., Angcang, Tang., Bi, Yang., Jianglan, Wang., Longqian, Liu. (2022). 1. Virtual reality-based vision therapy versus OBVAT in the treatment of convergence insufficiency, accommodative dysfunction: a pilot randomized controlled trial. BMC Ophthalmology, doi: 10.1186/s12886-022-02393-z
31. Singh, A., Saxena, V., Yadav, S., Agrawal, A., Ramawat, A., Samanta, R., Panyala, R., & Kumar, B. (2021). Comparison of home-based pencil push-up therapy and office-based orthoptic therapy in symptomatic patients of convergence insufficiency: a randomized controlled trial. International Ophthalmology, 41(4), 1327–1336. https://doi.org/10.1007/S10792-020-01689-7
32. T., Carvelho., Robert, S., Allison., Elizabeth, L., Irving., C., Herriot. (2008). 3. Computer gaming for vision therapy. doi: 10.1109/ICVR.2008.4625160
33. Tarek, Nehad., Tamer, Salem., Mohamed, Nagy, Elmohamady. (2018). 5. Combined Office-based Vergence Therapy and Home Therapy System for Convergence Insufficiency in Egyptian Children. The Open Ophthalmology Journal, doi: 10.2174/1874364101812010012
34. Tsering, Lamu, Shongmu., Zeeshan, Akhtar. (2024). 1. Prevalence of non-strabismic binocular vision anomalies (NSBVA) among university students of North India. Indian Journal of Clinical and Experimental Ophthalmology, doi: 10.18231/j.ijceo.2024.050
35. Xiong, L., & Wu, Y. (2024). Diagnostic values of questionnaires of Convergence Insufficiency Symptom Survey and College of Optometrists Vision Development Quality of Life in the screening of convergence insufficiency. International Journal of Ophthalmology.
36. Zoelfigar, Mohamed., Saif, Hassan, Alrasheed. (2023). 1. A Systematic Review and Meta-analysis of Convergence Insufficiency Prevalence and Management Options. The Open Ophthalmology Journal, doi: 10.2174/18743641-v17-20230712-2023-8
37. Зуева, М., Kotelin, V. I., Neroeva, N. V., Zhuravleva, A. N., & Цапенко, И. В. (2024). Virtual reality in visual rehabilitation. Российский Офтальмологический Журнал, 17(3), 113–118. https://doi.org/10.21516/2072-0076-2024-17-3-113-118