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IMPACT OF VIRTUAL REALITY EXPOSURE ON TEAR FILM STABILITY AND VISUAL FUNCTIONS: A REVIEW

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Abstract

Background: *Virtual reality technologies, which include equipment attached to a powerful computer with a high-resolution screen, are utilized in gaming, education, and professional settings, producing tear-film instability and affecting other visual capabilities like as visual acuity, color vision, and stereopsis.*
Objective: *The study aimed to assess how Virtual Reality exposure affects tear film integrity and visual functioning in young people.*
Methods: *We did a systematic analysis of PubMed and Scopus from 2021-2025, organizing data into categories such as tear film physiological processes, blinking behavior, VR-induced visual strain, accommodation-vergence conflict, stereopsis, and color vision alterations. Studies that did not provide visual or tear film assessments, used non-VR digital equipment, or lacked methodological clarity were excluded. The data was evaluated and summarized to identify common tendencies.*
Results: *Research indicates that virtual reality exposure leads to thicker tear film lipid layers and higher ocular temperatures. VR headset use lowers blink rate by 40-50 percent, although dryness does not vary much. VR can cause vergence and accommodation changes, resulting in minor myopic refraction and increased accommodation lag, particularly in people who already have binocular vision difficulties. Due to reduced accommodation amplitude, continuous VR exposure induces visual fatigue, eye strain, and simulator sickness. Transient IOP decrease was also observed, indicating potential for glaucoma treatment. Conclusion: Short-term exposure to virtual reality affects tear film, binocular system, accommodation, as well as visual fatigue. VR reduces near point of convergence (NPC) and near point of accommodation (NPA), however chronic usage produces eye strain, visual fatigue, and moderate simulator sickness. VR's periocular warming helps treat dry eyes and lowers IOP.*

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INTRODUCTION

VR seems an application of technology that allows humans to engage with computer-generated environments in an immersive way. VR has grown in popularity over the last several years for a number of reasons.[1] Furthermore, the introduction of VR games has aided the advancement of this technology, since players may feel a degree of immersion that is not achievable with regular gaming platforms. As VR applications expand fast, it is critical to understand its possible influence on eye health and investigate quantitative ways for monitoring its impacts. [2] Virtual reality (VR) tools use a headgear with a calibrated digital screen to offer stereoscopic view in a virtual environment. The gadget includes head tracking abilities, which allow the display to updated when the individual wearing it moves his/her head, creating a fully realized sensation. Virtual reality (VR) technologies include dedicated headgear that connect to powerful computers (for example, the Oculus Rift) as well as smartphone-based headgear with high-resolution screens. We previously showed oscillopsia using a virtual reality smartphone.[3]VR HMD screens give a field of vision of around 100° to 110°.[4, 5] VR may be defined as an innovation that allows for the substitution of the actual world with an artificial one, giving the user the impression that they are in another universe.[6] It is a set of techniques used to create computer-generated virtual environments in which individuals may participate and communicate as they would in real life. To do this, it combines stereoscopic displays, motion tracking technologies, input devices, and software platforms.[7]

VR can cause unpleasant symptoms including eyestrain, fainting, and other visual fatigue.[8] The main root cause of eye strain in VR is vergence-accommodation conflict (VAC).[9] The impacts of virtual reality on visual tiredness have been thoroughly explored utilizing questionnaires. Past study has also found a clear link among eye movement as well as visual fatigue. Variations in eye movement pace, fixation time, and blinking rate reflect weariness and mental stress.[10, 11]

The purpose of this comprehensive review is to look into the way VR exposure influences tear film stability and its impact on key ocular functions like visual acuity, accommodative ability, convergence mechanisms, color vision, and gross stereopsis, in order to highlight both the positive and negative ocular outcomes of VR use.

MATERIAL AND METHODS:

The present review article was created by methodically compiling, evaluating, and summarizing current data on the effects of virtual reality (VR) experience on tear film stability as well as visual functions. Relevant material was found by searches in major scientific databases such as PubMed, Google Scholar, ScienceDirect, and ResearchGate

INCLUSION CERITRIA:

- Articles from 2021-25.
- Young Adults of 14 to 35 years.

EXCLUSION CERITRIA:

- Studies before 2021.
- People younger than 14 years.
- People older than 35 years.

RESULTS

Recent studies suggest that VR has variable but mainly minor impacts on tear-film behavior. Okazaki and Yokoi (2025) found that a 30-minute VR gaming session raised tear-film lipid-layer disturbance grading from ~1.8 to ~2.6. Additionally, corneal and eyelid temperatures rose, indicating lipid-layer thickening and probable stability.[12]

Thus, VR may increase lipid-layer thickness in heated, enclosed circumstances, but contact-lens use results in a greater drop in tear stability.VR usage reliably lowers involuntary blinking. Kim et al. (2022) found that using a headset reduced blink rate from ~18.05 to ~10.81/min.[21]Although this decrease, subjective dryness remained basically unchanged: Okazaki et al. reported consistent VAS dry-eye ratings,

Frontier in Medical & Health Research

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while Lee and Hong (2022) showed no notable increase in OSDI after 40 minutes.[13]

In summary, while VR decreases spontaneous blinking (by ~40-50%), objective tear- film tests may stay steady, and subjective dryness ratings frequently indicate only minor or non-significant alterations following brief VR exposure. Immersive VR has the potential to cause significant adjustments in vergence and accommodation.

These data show that, whereas VR reduces blink rate by 40-50%, short-term exposure seldom causes noticeable dryness symptoms. Binocular coordination is similarly affected by short-term virtual reality. Alksnis et al. (2024) found that 20 minutes of VR gameplay led both NPC and NPA to retreat, with bigger changes observed in people with binocular abnormalities. VR caused a modest myopic shift, enhanced accommodation delay, and enhanced accommodative microfluctuations, exhibiting detectable vergence and accommodation strain regardless of a brief exposure. Stereopsis and binocular function are both affected in similar ways. Lin et al. (2022) discovered that merely 10 minutes of a 3D VR movie diminished stereoacuity and increased parallax angle by 12.55±1.65 arcsec.[14]

Lee and Hong (2022) noticed increased binocular tiredness sensations despite unchanged optical quality.[13]

Overall, VR's influence on stereopsis appears to be transient during exposure, however VR technologies are also being studied for therapeutic binocular training in clinical settings. Meanwhile, early trials of VR-based binocular training have showed moderate improvements in amblyopic acuity and stereopsis.[15] Reports frequently demonstrate an increase in visual fatigue and cybersickness with VR. Lee and Hong (2022) reported greater simulator-sickness scores in VR compared to 2D viewing (24), while Lin et al. reported nausea or dizziness in around 10% of participants following a brief VR roller-coaster clip. Objective tiredness signs were detected, including a decrease of ~1.85 D in accommodative amplitude. Symptoms such as eye strain, headache, and moderate nausea were prevalent. ome eye alterations detected during VR have therapeutic implications. Turnbull et al. (2019) found a significant increase in TBUT (+7.2±12.4 s) following VR, indicating possible application in dry-eye treatment. Okazaki et al.'s discovery of lipid layer thickening adds to the evidence for protective periocular warming effects. VR-based therapy tools have showed minor improvements in amblyopia, while Lin et al. documented an IOP drop of ~2 mmHg following VR, indicating potential benefit in glaucoma care. VR perimetry as well as oculomotor rehabilitation technologies are being developed.

These findings show that even short VR sessions can impact various ocular systems and cause detectable, albeit transitory, physiological changes.[14]

DISCUSSION

The increasing use of VR in playing and learning along with the treatment settings increases significant questions about the different methods in which the technology impacts ocular health among young people, who are among the most frequent users of immersive technologies. A increasing although still fragmented body of evidence from research published between 2021 and 2025 shows that VR exposure may influence tear film stability, accommodation, vergence, stereopsis, blink rate and subjective visual comfort.[2] Whole data imply that, most visual alterations caused by VR usage are transient, strain can be considerable and may emerge more clearly in some user groups or under specific viewing settings. The findings are given here along with further investigation of potential causes, literature discrepancies, consistency and an explanation of larger clinical and practical implications.

The pressure on the accommodative vergence system has been a major focus of current study. Yoon et al. (2021) found substantial declines in near-point accommodation and changes toward exophoria after two hours of smartphone-based VR exposure.[15] Banstola et al. (2022) and Dericioğlu & Kubat (2024) showed similar outcomes, reporting reduced near-point

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convergence and impaired stereopsis following short VR sessions.[16, 17]

Despite these alterations were of statistical significance their size remained minor indicating that VR causes functional tiredness rather than structural deterioration. Interestingly, individual predispositions seem to determine the intensity of binocular disruption. Dericioğlu and Kubat (2024) found that people with basic exophoria, diminished stereopsis or aberrant kappa angles had higher levels of pain and binocular strain.[17]

Hong and Kang (2024) revealed that incompatibility among a user's inter-pupillary distance and headset settings enhanced feelings of blurriness, dryness and heavy eyes.[18] The results of this study highlight the necessity of appropriate headset calibration, which is sometimes overlooked in consumer

VR use. Many of the symptoms reported in VR research stem from the well-known vergence accommodation conflict. Dymczyk et al. (2024) found that increasing levels of VAC resulted in much greater oculomotor pain, nausea and disorientation.[19]

These symptoms emerged despite the fact that objective measurements of phoria and accommodation were mostly unaltered indicating that discomfort may be caused by neural-perceptual conflict rather than mechanical pressure on the eyes. The literature also contains essential information about tear film behavior in virtual reality. Kim et al. (2024) showed substantial decreases in TBUT among soft contact lens wearers, but not among participants without lenses.[12] It might lend credence to the theory that VR surroundings can only weaken an already fragile tear film. Blink-rate studies show noticeable reductions during VR use which contributes to evaporative dry eye.[20]

Despite periodic advances in objective metrics such as the NIBUT, subjective dryness remains a prevalent complaint and both surface physiology and user perception must be evaluated.[13, 20]

Visual weariness, also known as asthenopia, has become one of the most commonly reported difficulties in VR research. Fan et al. (2023) discovered higher simulator sickness and tiredness during continuous-interaction activities.[2]

Lee et al. (2021) found higher accommodative microfluctuations and subjective strain following a brief session of VR exposure.[21] The repeated reports of fatigue suggest that VR places a considerable sensory burden on the visual system, particularly when visual tasks are challenging or the sessions are long.

Notwithstanding worries about eye strain, a number of research suggest that virtual reality may have therapeutic advantages. Godinez et al. (2021) showed that employing VR-based perceptual learning dramatically enhanced stereoacuity in both stereo- normal and stereo-anomalous observers.[22]

Shen et al. (2022) identified a strong correlation between VR-based measures of visual acuity and standard Snellen measures taken from uncorrected individuals.[23] These findings lend credence to the notion that VR may be more than simply a source of eye strain; it may also be a beneficial therapeutic and rehabilitative aid if used properly. Few physiological impacts is seen in VR investigations are not limited to the ocular health. Yoon et al. (2021) and Fan et al. (2023) found discombobulation along with nausea and dizziness related with vestibular visual mismatch. Lin et al. (2022) found that the most observed IOP drops following short-term VR exposure may sidelong contribute to visual unease by increasing cognitive load and decreasing tolerance for visual activities.[14] The findings are interesting but caution should be taken in clarifying them due to the short length of the measurements with no follow-up visits after the experiment. The most common methodological deficiencies of the studies analyzed were a small sample size, a very short exposure duration (mostly less than 30 minutes) and a lack of follow-up on regaining time following exposure. There are further concerns with device changeability as brightness, range of view, optical alignment and manner of assignation can significantly impact the findings.[2]

These attend to make between study evaluations difficult and point out a need for regularization in research protocols.

Frontier in Medical & Health Research

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The findings are interesting but caution should be taken in understanding them due to the short length of the measurements, with no follow-up following the experiment.

The most common methodological shortcomings of the studies analyzed were a small sample size, a short exposure duration (most of the time less than 30 minutes) and absence of follow-up on recovery time following exposure. There are further concerns with device changeability and substantially impact of the findings. Despite these restrictions, VR can temporarily intrude binocular coordination, reduce blink rate and change in tear film stability predominantly in contact lens wearers and induce signs of visual fatigue. While these effects do not appear harmful over the longer term but they emphasize the need of adequate usage of VR. Frequent breaks can substantially reduce discomfort as well as correct adjustment of inter pupillary distance, session duration control and cautious use by visually vulnerable people.

While it creates short-term disruptions to visual function and comfort, it also provides promising opportunities for visual rehabilitation, screening, and perceptual training.[22]

The data from 2021 to 2025 emphasizes the importance of balanced and educated VR use as well as the need for more study to elucidate its long-term consequences as VR becomes increasingly incorporated into gaming, education, medical and immersive professional development.

CONCLUSION

VR has a noticeable influence on your eyes after only a short time of use. It causes a variety of alterations to the tear film, binocular system, accommodation, and visual fatigue, the majority of which are transient but clinically evident. Evidence suggests that VR's influence on tear-film stability varies: while blink rate reduces dramatically, the confined and warmed environment of VR headsets can increase lipid-layer thickness and may assist preserve or somewhat improve tear stability in those with normal ocular surfaces. Those who use contact lenses or have underlying evaporative difficulties, on the other hand, may have a shorter tear breakdown time, making them more prone to dryness while using VR. VR viewing regularly alters accommodative and vergence functions, with studies showing decreased NPC and NPA, increased accommodative latency, and increased microfluctuations—all markers of ocular strain and weariness. Temporary decline in stereoacuity has also been seen, indicating short- term disruptions in fine binocular synchronization. VR use often causes eye strain, visual fatigue, disorientation, and moderate simulator sickness. These experiences are confirmed by significant decreases in accommodative amplitude and increases in subjective discomfort, despite the fact that most tear-film and ocular-surface characteristics remain mostly unchanged after brief exposures. Notably, several studies suggest to possible VR therapeutic advantages, such as periocular warming, which may aid in dry-eye management, short-term decreases in intraocular pressure, and the expanding use of VR in amblyopia and binocular-vision rehabilitation. VR causes reversible changes in tear film dynamics, binocular function, accommodation, and visual comfort. These effects are particularly pronounced in people with pre- existing ocular problems. Simultaneously, VR has potential as a clinical tool, necessitating more study to evaluate long-term safety and wider therapeutic uses.

REFERENCES

DJSCOE V-P. Mumbai, Rajesh Desai P, Nikhil Desai P, Deepak Ajmera K, Mehta K. A Review Paper on Oculus Rift-A Virtual Reality Headset IJETT. 2014;13(4):175-9.

Fan L, Wang J, Li Q, Song Z, Dong J, Bao F, et al. Eye movement characteristics and visual fatigue assessment of virtual reality games with different interaction modes. Frontiers in Neuroscience. 2023;17:1173127.

Randall D, Griffiths H, Arblaster G, Bjerre A, Fenner J. Simulation of oscillopsia in virtual reality. The British and Irish Orthoptic Journal. 2018;14(1):45.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Owen CB, Zhou J, Tang A, Xiao F, editors. Display-relative calibration for optical see-through head-mounted displays. Third IEEE and ACM international symposium on mixed and augmented reality; 2004: IEEE.

Cakmakci O, Rolland J. Head-worn displays: a review. Journal of display technology. 2006;2(3):199-216.

Casas S, Portalés C, García-Pereira I, Fernández M. On a first evaluation of romot— A robotic 3D movie theatre—For driving safety awareness. Multimodal Technologies and Interaction. 2017;1(2):6.

Parisi T. Learning virtual reality: Developing immersive experiences and applications for desktop, web, and mobile: " O'Reilly Media, Inc."; 2015.

Hua H. Enabling focus cues in head-mounted displays. Proceedings of the IEEE. 2017;105(5):805-24.

Iskander J, Hossny M, Nahavandi S. Using biomechanics to investigate the effect of VR on eye vergence system. Applied ergonomics. 2019;81:102883.

Kim D, Choi S, Choi J, Shin H, Sohn K, editors. Visual fatigue monitoring system based on eye-movement and eye-blink detection. Stereoscopic Displays and Applications XXII; 2011: SPIE.

Bang JW, Heo H, Choi J-S, Park KR. Assessment of eye fatigue caused by 3D displays based on multimodal measurements. Sensors. 2014;14(9):16467-85.

Kim H, Gil M, Kang H. Tear Film Break-Up Time before and after Watching a VR Video: Comparison between Naked Eyes and Contact Lens Wearers. Electronics. 2024;13(13):2448.

Lee J, Hong H. Effects on ocular dryness and optical quality when watching movies using a virtual reality device. J Korean Ophthalmic Opt Soc. 2022;27:297-304.

Lin C-H, Lin H-C, Chen C-Y, Lih C-C. Variations in intraocular pressure and visual parameters before and after using mobile virtual reality glasses and their effects on the eyes. Scientific Reports. 2022;12(1):3176.

Yoon HJ, Moon HS, Sung MS, Park SW, Heo H. Effects of prolonged use of virtual reality smartphone-based head-mounted display on visual parameters: a randomised controlled trial. Scientific Reports. 2021;11(1):15382.

Banstola S, Hanna K, O'Connor A. Changes to visual parameters following virtual reality gameplay. The British and Irish Orthoptic Journal. 2022;18(1):57.

Dericioğlu V, Kubat B. Effects of virtual reality usage on kappa angle, accommodation, pupil, depth perception, and examination of the relationship of these parameters with discomfort perception. Marmara Medical Journal. 2024;37(1):59-62.

Hong H, Kang H. Investigation of the effect of the alignment of the eye and the virtual image of virtual reality on fatigue in viewing VR device. Journal of the Society for Information Display. 2024;32(11):747-54.

Dymczyk M, Przekoracka-Krawczyk A, Kapturek Z, Pyżalska P. Effect of a vergence-accommodation conflict induced during a 30-minute Virtual Reality game on vergence-accommodation parameters and related symptoms. Journal of Optometry. 2024;17(4):100524.

Marshev V, Bolloc'h J, Pallamin N, Cochener B, Nourrit V. Impact of virtual reality headset use on eye blinking and lipid layer thickness. Journal francais d'ophtalmologie. 2021;44(7):1029-37.

Lee SH, Kim M, Kim H, Park CY. Visual fatigue induced by watching virtual reality device and the effect of anisometropia. Ergonomics. 2021;64(12):1522-31.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Godinez A, Martín-González S, Ibarrondo O, Levi DM. Scaffolding depth cues and perceptual learning in VR to train stereovision: A proof of concept pilot study. Scientific reports. 2021;11(1):10129.

Shen T-W, Hsu H-Y, Chen Y-Z. Evaluation of visual acuity measurement based on the mobile virtual reality device. Mathematical Problems in Engineering. 2022;2022(1):1270565.