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Effect of Illumination Over Fusional Vergence – A Narrative Review

Authors
Raisul Azam, Gaurav Kumar Bhardwaj, Sourav Karmakar, Animesh Mondal
Department of Optometry and
Vision Science, Amity Medical
School, Amity University, Haryana, India

Abstract

Introduction: *Most of the studies shows that illumination is one of the important aspects in our working environment as well as while reading and writing. A low illumination can affect the various ocular parameters like accommodation, vergence, reading speed also and to find out what should be an optimal level of illumination and type of illumination to be used. Convergence and illumination have significant relation with change in pupil size. In low illumination as pupil size increase with that depth of focus decreases, which leads to cause more exertion on accommodation and convergence which causes visual fatigue symptoms.*

Objective: *The objective of this article was to update on recent investigationshow illumination effects the fusional vergence and other ocular status. Therefore, conducted a search of the studies published about the same.*

Method: *A bibliographic search was conducted limited to publication referring to illumination and their effects on ocular status using the data base of PubMed, Research Gate, Google scholar. Different strategies were there for selecting articles.*

Conclusion: *The conclusion of the review was that mostly the accommodation, convergence and fusional vergence. In fusional vergence mostly positive fusional vergence which were changed with change in the illumination, and a proper intensity of illumination as well as position of illumination is important for an effective work environment to reduce different kind of ocular symptoms. As Lighting influences users' visual strain and well-being. Therefore, creating awareness regarding lighting that ensures visual work conditions do not result in visual fatigue is a preventive activity.*

Keywords: *Illumination, Positive fusional Vergence, Negative fusional Vergence, Accommodation.*

Key Messages (Provide appropriate messages of about 35-50 words to be printed in centre box):

As Illumination plays an important role in our life. Its standards and their position has important role in work efficiency, reading and writing speed by increasing our visual comfort. As our vergence and accommodation are affected with different levels of illumination which can be a cause for significant ocular changes.

Introduction

1. Illumination

Illumination is an important aspect of workplace, as it can effect on working condition and performance of the worker. In different level of illumination ocular status may get affected and the proper level and position of illumination is needed for optimum functioning by workers.

Various sources of illumination have been proposed as the ideal standard for reading.

Various studies and authority recommend various illumination levels for different task in industries. Various researchers, appears to have differing opinions on the amount of light required for certain tasks. [1–4]

Indian Standard Code of Practice for Industrial Lighting have suggested that for Reading and writing it should be 300-400 lux and in 2011 National Electric Code of Indian standards they suggested for reading illuminance should be 300-700 lux and Central Building research institute of India suggests 200- 500 lux for task like reading.[5]

Lighting influence's the well- being of users and their visual strain too. As a result, ensuring that visual task circumstances don't lead to visual tiredness is a preventative task.[6] The use of Video Display Terminals (VDTs) has grown in popularity as information and advanced technology have advanced. Personal computers (PC) or flat panel displays have become commonplace in the business and at home. VDT use has been linked to a variety of ocular complaints, including eye strain, headaches, concentrating issues, and dry eye.[7]

ii. Near Triad - Synkinesis

The accommodation reflex is a visual response that allows you to focus on objects that are close to you. The accommodation-convergence reflex, sometimes known as the close reflex, [8,9] is another term for it.The eye's power changes when these three processes are coordinated, allowing the eye's centre of focus to shift from a distance to a near object or vice versa.[10]

iii. Fusional Vergence –

Fusional vergence testing is a clinical technique for determining the value of positive and negative fusional vergence.[11] This test examines the quantity of fusional reserve strength the individual can rely upon to maintain fusion by gradually increasing prism power. The base in prism causes a spatial shift, making the clear image of target to blur, causing a demand to diverge, whereas the base out prism has the reverse effect. [12]Generally, the individual is requested to report when they start to see a blur, double image, and then one single picture during the testrecovery. The blur point is understood as the fusional vergence limit, as well as the start of accommodative changes-dependent vergence.[13]

While it may appear on the surface that convergence along with divergence are just opposing vergence movements of the same underlying mechanism.[14] When prisms are positioned in front of the eyes, the tonic condition of the extraocular muscle's changes, thefixation disparity increases, andfusional amplitude also increases. The act of blocking one eye, causing a fusion breakdown, or decreasing the prisms causes a gradual restoration to the original position.[12]In cases of anisometropia and substantial phorias, prism adaptation plays a critical role in preserving binocular fusion. There is tendency of some patients to require high amounts of prim power to decrease the symptoms can all be explained by vergence adaptation.[14] Clinical practise in diagnosing and treating binocular vision defects relies heavily on fusional amplitudes.[15] Both the accommodation and convergence process must be sufficient to maintain a clear single image when reading or conducting close work. If these systems fail, individuals may experience accommodative and/or vergence dysfunction, resulting in a variety of symptoms.[16] Only when the interplay between the accommodation and vergence systems is optimal can clear vision be obtained.[17]

iv. Accommodation –

Accommodation or Near reflex it consist of three parts or reflex which brings near target objects into focus with thickening of our crystalline lens, with pupil constriction and inward movement of eyes. This makes the near target into focus.[18]

The objective of this review article was to know the effect of fusional vergence when there is a change in illumination. In different level of illuminations, how fusional vergence is getting affected. To know about proper level of illuminations and their position and its effect on different ocular parameters. And how improper

illumination can lead to various ocular symptoms and can reduce efficiency in work and studies.

2. Method –

Inclusion Criteria – Only those articles were selected that were appropriate and shows a relationship between changes in illumination and their effect on ocular status.

Exclusion Criteria – Articlesshowing different systemic changes i.e.,affecting the other body organs or changes in that rather than eyes or ocular status with change in level of illumination were excluded.

A bibliographic search was done using the data base PubMed, Google Scholar, Research Gate. Different strategies were there for selecting the article

Strategy 1- Illumination and Fusional Vergence

Strategy 2- Illumination and Change in Ocular Status

Strategy 3- Illumination and different occupations

Filters were also used while searching article to search related articles only. One those articles were selected which were appropriate and were related to our topic. And those articles having open access available were downloaded and then reviewed.

3. Results –

A list of 50 articles were searched in which 30 were selected which was related to the topic and 20 article which were unrelated were rejected. The study that was selected in this review article showed that there is an effect of illumination over fusional vergence and as the illumination is changed our ocular status is changed. In a study which was done in three different illuminations while watching a 3D movie in those illumination.it shows that there were changes in negative fusional vergence and some ocular status like accommodative micro fluctuations. And the front level of illumination is best position for reading and writing purpose as it adequate and proper level of illumination can be manged. And with the proper level of illumination the visual performance can be improved as well as the symptoms can also be reduced.

4. Discussion –

Previous studies by Chiranjib Majumder and Lavanya Sinathamby, [19] discovered a link between fusional vergence and the room illumination mainly in positive vergence in their research.The results confirmed that the quantity of positive fusional vergence rose as room illumination decreased. The observers were Yuanyuan Chen, Yuwen Wang et all,[20] who viewed 3D TV in three different illumination modes. The visual status, comprising positive and negative relative accommodation, positive and negative fusional vergence, distance and near phoria, gradient AC/A and, accommodative facility it was determined before and after a break of 90-minute 3D viewing period in each different method. Overall, they discovered that Method B (back lighting) and Method C (front illumination) had the same effect on several visual status measurements; both modes were preferable than Method A (total darkness) in terms of causing less change after 3D viewing. Method C also resulted in the lowest change in accommodating micro fluctuation. When the shift in ocular condition is considered, they conclude that the front position of illumination method is much more suitable for shutter 3D TV viewing. Yuki Okada, Takehito Kojima et all conducted a study [21]They calculated the patients' convergence and accommodation while they were looking at a 3D object in two different illumination conditions at the same time. All the subjects' measurements yielded similar results. The maximum diameter of pupil was 3.51 mm, though the minimum diameter of pupil was 2.65 mm in this condition. The convergence and accommodation changed concurrently through a 10s cycle, which related to the virtual 3D object's movement cycle. The value of accommodation, on the other hand, went beyond the value of convergence. The pupil diameter reached a maximum of 4.71mm in this circumstance. The pupil diameter was measured at

a minimum of 4.07 mm. When compared to the light environment, the diameter of pupil was dilated in this situation. The convergence and accommodation fluctuated simultaneously through a 10s cycle, which was related to the sequence of virtual 3D object's movement as well as the cycle of the light surroundings. As a result, the accommodation and convergence values were nearly identical. In their 1991 paper "Effect of Luminance on the Relationship Between Accommodation and Convergence," B C Jiang 1, K W Gish et all [22] developed the terms Dark Focus and Dark Vergence. Both the accommodation and convergence tend to move toward new and different typical resting positions when brightness is reduced, which are usually termed as dark convergence and dark focus. Accommodation haven't shift much from the distance target as the brightness of a binocularly seen spot rose. Fusional vergence, on the other hand, steadily transitioned from dark-vergence to target position. Mono ocular focus tends to remain at the specific dark focus at lower brightness levels, whereas binocular focus managed to correlate to the distance target. KS Wolf, HE Bedell, and S B Pedersen[23] According to earlier studies, the resting posture of accommodation and vergence are uncoupled in darkness, but the question is whether the synkinesis of accommodation and convergence occurs when both systems are deprived of stimulus or illumination, i.e., in darkness. The mean resting positions of accommodation and vergence were marginally associated (r = 0.19), as were spontaneous fluctuations of accommodation and vergence in darkness (median r = 0.15). However, using clinically determined distance phoria and the resting posture of accommodation, resting vergence postures may be predicted (r = 0.65). when the AC/A ratios of the patients were considered, we find that the continuation of synkinesis is compatible with the relaxation of accommodation and vergence to different resting positions in darkness. In their study Impacts of Visual display unit Workstation Lighting Environments on Worker Visual Job, Chiu Hsiang Joe LIN, Wen-Yang et all [24] discovered that subjective visual tiredness was substantially connected to colour lighting on all questions. Participants, on the other hand, reported seeing more. They felt fatigued when working in red and green coloured illumination, along with they favoured blue light over other colours. The goal of this research was to see how the presence of various coloured lighting conditions affected visual performance on VDT tasks. Coloured lighting has a substantial impact on visual acuity; blue lighting performed the best. However, the effect of human psychology should be addressed while changing the colour of lighting in the workplace. Ambient illumination levels have a considerable impact on target reaction times, with the level of illumination 20 lux providing the greatest results. While low illumination saves energy, it is more important to see that better lighting condition will improve human visual functioning, protection, physical condition, and well-being, as well as reduce the rate of accidents and absenteeism. Agnieszka Wolska [6] conducted a study. The study's goal was to develop several lighting techniques for use with visual display terminals and see how they affected users' visual performance and preferences. The study found that indirect and multiple lighting techniques caused the least visual strain. In terms of ocular fatigue, indirect and multiple lighting systems are highly effective. However, when it comes to antiglare task lighting, a multiple lighting method should be employed with caution. The findings suggest that, regardless of the lighting arrangement, 1.5 hours of Visual display terminal work (with ocular consideration mostly on the display) can elicit small to significant asthenopia symptoms. The different lighting system influences increase in sensitivity to light, eyelid heaviness, tiring of eyes and redness also. Multiple and direct-indirect lighting systems were found to have significantly higher levels of complaints. As a result, they should be utilised with extra care to ensure proper antiglare

implementation. In their study on Accommodation and visual acuity in night driving illumination levels, P. ArumiK.Chauhan and W.N. Charman [25] discovered that at luminance levels for road lighting is about 1 cd/m2 and was equal to those suggested, acuity fell from 6/6 to 6/9, with a little shift in calculated refraction. Only when the luminance was decreased to below 0.03 cd/m2 did noticeable alterations in refraction having night myopia, become apparent, much less than while driving at night under regular conditions. The absence of any major night myopia was confirmed in direct trials under street lighting circumstances. As a result, it is believed that brain alterations, instead of night myopia, they are usually blamed for the acuity loss faced by drivers while night driving. Ayşe Nihan Avc and Pek Memikolu published article on how ELED Lighting effects on ocular Comfort while having Reading Task.[26] The purpose of this study was investigating the impact of LED lighting illuminance levels ocular comfort of different users. Eighty students from Ankaya University's Department of Interior Architecture took part in three lighting scenarios using LED lighting. The situations were 200 lux, 500 lux, and 800 lux. Each lighting condition is assessed using six visual comfort factors while doing a reading activity. According to the findings, LED lighting with three different illuminance levels has varied effects on visual comfort. Lina Chin-Chiuan [27] and Huang Kuo-Chenbdiscovered that lighting intensity had a substantial effect on mean % in their study Effects of different Lighting Colour, changes in Illumination Intensity, and the written Text Colour on ocular Performance. Under 500 lux, the average percentage was higher than under other lighting intensities. The American Illumination Engineering Society [28] recommends a lighting intensity of 750 lux for ordinary office work, German DIN recommends 500 lux. Läubli et al. found similar results.[29] then Stammer john et al. [30], he discovered that most departments are approximately 500 lux, which is also consistent with earlier studies' findings that illumination intensity did have a substantial impact on visual performance. The goal of Male Shiva Ram and Rishi Bhardwaj's study [5] was to assess ocular functioning during reading in various illumination sources. We discovered a weak relationship amongst lighting type and reading speed. Though, their results reveal that most males (85%) favour CFL and most females favour CFL. FLUO is preferred by 65% of respondents over LED and TUNG lighting. While LED lighting is energy saving and cost efficient, it has poor visual performance and is not ideal for prolonged visual tasks such as writing and reading since it can produce early visual fatigue. Both TUNG and LED illuminations caused the most visual pain.

Conclusion

The conclusion of this review article is that there is an effect of illumination on fusional vergence and on other ocular status. A higher positive fusional vergence can lead to asthenopia. The position of illumination also plays an important role on the ocular status, mostly affects the accommodative function. It is reported that if the level and position of illumination are good and proper the visual performance can be increased, and the work efficiency will also increase. There is an effect on accommodation and convergence when the illumination of a 3D screen is changed. If we compare between different position of illuminations like overhead, back and front, the front illumination will be the most effective as it will lead to less ocular changes and will have less ocular fatigue ness and the ocular symptoms such as asthenopia, eyestrain, accommodative micro fluctuations, fusional vergence will be less affected.The type of illumination and colour affect the user's lifestyle like working environment, their reading and writing task also get affected. A proper lighting at the works place can increase the work efficiency as well as the safety of the workers. A proper illumination will reduce eye strain, visual fatigue. A proper level of illumination is also important like in LED with 500 Lux of illumination is optimal for reading and

writing task. And for industrial lighting it is suggested 300-400 for normal reading and writing task. Indian Standards suggest that the lighting for reading should be 400-700 lux to have a comfort and effective environment. Illumination is an important factor because most of user's use visual display terminal screen in which more than 1.5 hours of work can cause of asthenopia symptoms, redness, eyestrain, and fatigue. These symptoms can be reduced with proper level of lighting, proper type of illumination and position of illumination should be proper. So, a proper level of illumination and position will increase the visual comfort and decrease the symptoms of fatigue ness and will reduce the changed in ocular status which can happen due to low level of illumination.

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