Journal of Optometry and Ophthalmology
Yogalakshmi SBK, et al., 2022-J Opto Ophth
Research Article

Effects of Continuous Online Multiplayer Gaming on Ocular Health

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Abstract

Purpose: To study the ocular effects of continuous online multiplayer gaming and reading using smartphones.

Methodology: In the study, inclusion criteria were 25 active gamers and 25 readers between the ages of 18 to 25 years of either sex, and the Indian population with ametropia < ± 4.00D sph and -1.25 cyl. Exclusion criteria were subjects with a history of non-strabismic binocular vision anomalies, ocular surgery, strabismus, ocular trauma & pathologies, and systemic illness. The GAMERS were allowed to play PUBG for 2hrs, and READERS were allowed to read for 2hrs on their smartphones. The pre- and post-activity values were collected and analyzed using SPSS software.

Results: There were significant changes in NPC with accommodative target and RG filter, monocular and binocular accommodative amplitudes, monocular and binocular accommodative facility, and vergence facility (Wilcoxon signed-rank test, $p<0.05$) among the GAMERS and READERS. No significant change in accommodative response, vergence amplitudes, tear film volume, and stability. The differences observed between the pre- and post-activity values of the binocular vision and tear film parameters were the same when compared between GAMERS and READERS (Mann Whitney U test, $p>0.05$).

Conclusion: The ocular effects of GAMING are similar to continuous READING on mobile phones. However, the addictive nature of the activity "GAMING" could aggravate the ocular symptoms of exhaustive use.

Keywords: Non-strabismic binocular vision anomalies (NSBVA); Multiplayer online gaming; Smartphone; Video games, Internet gaming; Eyes.

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Received Date: 09-08-2022
Accepted Date: 10-19-2022
Published Date: 10-29-2022

Introduction

Times have changed, and many people of all ages use their free time for digital entertainment. Going without the use of phones for even a day or two is extremely rare. Smartphones have become an entertainment center rather than just a communication device. Internet games are the modern playgrounds, and exhausting use can lead to Internet gaming disorder.

Citation: Yogalakshmi SBK, Anand M, Gupta D. Effects of Continuous Online Multiplayer Gaming on Ocular Health. J Opto Ophth. 2022; 3(1):1-10.
DOI: https://doi.org/10.37191/Mapsci-JOO-3(1)-021

Internet Gaming Disorder (IGD) is "persistent and recurrent use of the Internet to engage in games, often with other players, leading to clinically significant impairment or distress." In addition, many individuals who spend extended periods at video display terminals report a combination of eye and vision issues. With more than 20 million gamers worldwide, it is now considered the most popular genre of internet gaming, with the numbers expected to increase in the future. However, as the gaming industry continues to evolve, it has become more sophisticated and interactive, making the players spend hours together in front of VDUs (mobile/ laptops/ computers) [1].

In today's screen-centric world, kids and adults search for the latest gaming platforms with the highest processing internet and fastest surfing speed [2]. An average Indian online gamer is below 24 years with male gender predominance [3]. According to the Economic Times report, Indians spend roughly 3 hours a day on smartphones, and in 2015, data reported that the digital games market in India decreased to mobile gaming [4]. Already Visual display units (VDUs) have become a part of daily life, like working, studying, and leisure activities, with an increasing preference for smaller-screen devices, such as tablets, laptops, and smartphones; it will lead to increased eye problems like visual disorders, ocular surface disorders, and asthenopic symptoms [5]. Using digital devices frequently can cause eyestrain, dry eye, and pain in the neck and shoulder; such symptoms are due to glare and low contrast, which force the eyes to work harder than they usually need. Video games, especially smartphones, require the constant focus of the eyes, following small details, and the use of closer working distance that can result in amplified asthenopic symptoms and signs [6]. The above symptoms may increase the demand for ocular accommodation and vergence. Usually, in the interest of playing games, they forget to blink their eyes; this causes a decrease in the blink rate, which may cause dryness and irritation, which can sometimes lead to an evaporative dry eye [7]. A narrative review on internet gaming disorder (IGD) reported that the severity and prevalence of IGD are higher in Asian countries than in the West [1]. A report by KPMG in India and Google in May 2017 reported that the Indian online gaming industry would add 190 million gamers [8]. A study on Video Game Vision Syndrome among children reported that 85.5% of patients playing video games had asthenopia, a lower percentage of stereopsis (62.3% positive on the Lang-Stereotest I, 71.0% positive on the Lang-Stereotest II), a higher prevalence of heterophoria (22.5%), and 83.1% of refractive error in the dominant eye [9]. Considering the growing population of online gamers, it has become essential to study the detrimental effects of continuous usage on ocular health. Though there have been studies reporting the effects of excessive digital gaming, which involves online multiplayer games, more petite, has been understood about its effect on ocular health. Though the adverse effects are known, the use of mobile cannot be controlled, be it to read or play. Therefore, the study aims to understand the change in visual parameters that can be affected due to chronic mobile use. The measured pre- and post-activity parameters were also compared between the reading and gamer groups to understand if the presented dynamic stimuli caused additional damage to the visual system.

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Methodology

The research adhered to the tenets of the Declaration of Helsinki and received approval from the institutional review board and the institution's ethics committee. All the participants signed informed consent before the pre-test assessment. The sample size was 50 (25 subjects for the gamers and 25 for the reader's group) [10], and subject recruitment was by snowball sampling. The subjects enrolled underwent a preliminary eye examination and orthoptic evaluation by a trained optometrist [11]. In addition, sensory tests such as WFDT and stereopsis are performed [12]. The motor evaluation includes an extraocular muscle motility test [13], prism bar cover test (PBCT), MEM retinoscopy, negative relative accommodation (NRA), positive relative accommodation (PRA), near the point of accommodation (NPA), near the point of convergence (NPC), accommodative facility (AF), negative fusional vergence (NFV), positive fusional vergence (PFV), MIM (muscle imbalance) [14] and vergence facility with 3BI /12BO flip prisms for near [15], the amount of accommodative induced convergence per unit of accommodation (AC/A ratio) was calculated [16]. The subjects who knew how to play PUBG were in the "GAMERS" cohort, and subjects interested in reading joined the "READERS" cohort. The subjects in the GAMERS group were allowed to play "PUBG" on a Smartphone (6 inches on a standard android phone) for 2 hours without a break [17]. Similarly, the subjects in the READERS group were given reading material on a Smartphone and were allowed to read for 2 hours [18]. In addition, all the subjects underwent complete orthoptic and tear film volume and stability evaluation, including Schirmer's, TBUT [19], blink rate [20] pre- and post-activity, and the post-test values were collected immediately after the activity.

Inclusion Criteria	Exclusion Criteria
• Age 18-35 years	• Below 18 years and above 35 years
• BCVA of 6/9 or better, N6 at 35-40cm	• BCVA less than 6/9, less than N6
• Refractive error < ±4.00 D	• Refractive error > ±4.00 D.
• No asthenopic symptoms	• Strabismus, NSBVA, ocular trauma, ocular pathologies and systemic illness.

Table 1: Inclusion and Exclusion Criteria.

Results

Fifty subjects were enrolled in the study (25 gamers and 25 readers) between the ages of the mean (SD) of 20 (1.3) years, out of which 24 were females, and 26 were males. The measured parameters were set among the groups before and after the activity. No changes were observed in the refractive error pre- and post-activity among the readers and gamers. The median (IQR) of refractive error in the gamers (Sphere: 0.00 (3.00) Cylinder: 0.00 (2.50)) and in the readers (Sphere: 0.00 (3.50) Cylinder: 0.00 (0.75)).

Binocular vision parameters

The readers and gamers had no difficulty performing the sensory tests pre- and post-activity. There was no change in the stereopsis and WFDT for distance and near. Similarly, the groups did not show any

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changes in the phoria status pre- and post-activity.

Accommodative parameters

The gamers showed significant differences in the following accommodative parameters (Table 1). The monocular accommodative amplitude of both eyes showed significant difference. The monocular near point of accommodative receded post activity in the gamers (Right eye: Wilcoxon signed rank test, Z=-2.355, p=0.019 and left eye: Wilcoxon signed rank test, Z=-2.135, p=0.033).

Parameters (units)	**Gamers**		**Readers**	
	Pre-Median (IQR)	Post Median (IQR)	Pre-Median (IQR)	Post Median (IQR)
AC/A ratio	6.20 (0.90)	6.20 (0.90)	6.10 (1.0)	6.10 (1.)
NPC with the accommodative target (cm)				
Break	5.50 (5.0)	7.0 (8.50)	5.50 (2.50)	6.50 (6.0)
Recovery	7.0 (4.5)	8.0 (9.50)	7.00 (2.50)	8.00 (6.50)
NPC with RG filter (cm)				
Break	8.0 (7.0)	9.0 (7.0)	7.0 (7.0)	8.50 (9.0)
Recovery	10.0 (7.0)	11.0 (7.0)	9.0 (7)	10.50 (8.50)
Accommodative amplitudes				
Right eye	14.28 (6.66)	12.50 (10.91)	14.28 (7.57)	11.11 (8.97)
Left eye	13.33 (6.66)	12.50 (11.31)	13.33 (8.33)	11.11 (8.72)
Both eyes	12.80 (9.79)	11.76 (11.67)	12.50 (8.66)	10.00 (8.33)
NRA	3 (1)	3 (1)	3 (1.25)	3 (1.25)
PRA	-2.75 (1.75)	-2.75 (5.75)	-3.00 (1.50)	-3.00 (1.50)
MEM Right eye	0.50 (0.50)	0.50 (0.50)	0.50 (0.50)	0.50 (0.50)
MEM Left eye	0.50 (0.50)	0.50 (0.75)	0.50 (0.25)	0.50 (0.25)
MAF Right eye	14.0 (10.0)	11.0 (12.0)	12.50 (11.0)	11.0 (8.50)
MAF Left eye	13.5 (11.0)	11.0 (12.0)	13.0 (11.50)	11.50 (12)
BAF	14.50 (9.0)	11.0 (12.0)	14 (14.50)	11.50 (13.50)
NFV distance				
Blur	0 (0)	0 (0)	0 (0)	0 (0)
Break	10 (19)	12 (14)	8 (14)	10 (10)
Recovery	6 (16)	10 (14)	6 (14)	8 (12)
NFV near				
Blur	0 (0)	0 (0)	0 (0)	0 (0)
Break	14 (15)	16 (17)	17 (15)	18 (15)
Recovery	12 (10)	14 (14)	14 (14)	16 (18)
PFV distance				
Blur	0 (0)	0 (0)	0 (0)	0 (0)
Break	25 (28)	30 (20)	20 (20)	25 (25)
Recovery	20 (25)	25 (19)	16(19)	20 (29)
PFV Near				
Blur	0 (0)	0(0)	0 (0)	0 (0)
Break	20 (30)	30 (20)	34 (20)	22 (20)
Recovery	25 (25)	25 (17)	22 (16)	21 (18)
Vergence facility	16 (22)	14 (24)	17 (17)	15 (14)

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Table 2: PRE and POST activity values of Binocular vision. NPC-Near point of convergence, R/G filter-Red and green filter, MAF-monocular accommodative, BAF -Binocular accommodative amplitudes, NRA-Negative relative accommodation, PRA-Positive relative accommodation, NFV-Negative fusional vergence, PFV-Positive fusional vergence.

The monocular and binocular accommodative facility reduced following the performance of task (Right eye: Wilcoxon signed rank test, Z=-3.716, p<0.0001; left eye: Wilcoxon signed rank test, Z=-3.995, p<0.0001; both eyes Wilcoxon signed rank test, Z=-3.425, p=0.001). Similar response observed even in the readers group. The readers had significant differences in the monocular and binocular near point of accommodation (Right eye: Wilcoxon signed rank test, Z=-3.520, p<0.0001; left eye: Wilcoxon signed rank test, Z=-2.945, p=0.0043; both eyes Wilcoxon signed rank test, Z=-3.425, p=0.005). Significant reduction in the monocular and binocular accommodative facility post activity (Right eye: Wilcoxon signed rank test, Z=-3. 275, p=0.001; left eye: Wilcoxon signed rank test, Z=-3.356, p=0.001; both eyes Wilcoxon signed rank test, Z=-3.870, p<0.0001).

Vergence parameters

Among the gamers, significant differences noted in the following vergence parameters. The subjective response of near point of convergence (NPC) with accommodative target (Break: Wilcoxon signed rank test, Z=-2.712, p=0.007 and recovery: Z=-2.801, p=0.005) and recovery response of NPC with R/G filter (Recovery: Wilcoxon signed rank test, Z=-2.606, p=0.009). Among the readers, significant differences were noted in the NPC with accommodative target (Break: Z=-4.132, p<0.0001, Recovery: Z=-3.779, p<0.0001) and NPC with R/G filter (Break: Z=-3.846, p<0.0001, Recovery: Z=-3.721, p<0.0001). Near point of convergence receded following the activity among the readers and gamers.

The negative fusion vergence (NFV) amplitudes for near showed significant difference among the gamers (NFV Break: Z=-2.832, p=0.005 and NFV recovery Z=-2.576, p=0.010). Similarly, distance positive fusional vergence amplitude (PFV Break: Z=-3.742, p<0.0001 and PFV recovery Z=-3.637, p<0.001) and near positive fusional vergence amplitudes (PFV Break: Z=-3.500, p<0.0001 and PFV recovery Z=-2.292, p=0.022) had significant difference post the activity. However, following activity there was improvement in the vergence amplitudes noted. Among the readers, the negative fusional vergence for distance showed significant difference (NFV Break: Z=-3.331, p=0.001 and NFV recovery Z=-3.536, p<0.0001). The positive fusional vergence amplitudes for distance (PFV Break: Z=-2.959, p=0.003 and PFV recovery Z=-2.954, p=0.003) and near (PFV Break: Z=-3.330, p=0.001 and PFV recovery Z=-3.411, p=0.001) had statistically significant differences pre and post activity. Similar to the gamers, the readers had improved vergence amplitudes post activity. The vergence facility reduced following the activity among the gamers (Z=-3.305, p=0.001 and readers (Z=-3.563, p <0.0001).

Tear film parameters

There was no significant difference in the gamers' pre- and post-activity tear film measurements. However, the readers showed statistically significant differences in the left eye schirmers with paracain (Z =-2.203, p=0.028 and without paracain (Z=-

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2.375, p=0.018), reduced tear film quality post activity.

Gamers VS Readers

The differences between pre- and post-values of all the binocular vision and tear film parameters did not show any significant differences between the gamers and readers (Man Whitney U test, p>0.05). There was a difference in the blink rate noted (p=0.001), with gamers having a lesser blink rate compared to the readers (Table 2).

Parameters (units)	Gamers		Readers	
	Pre-Median (IQR)	Post Median (IQR)	Pre-Median (IQR)	Post Median (IQR)
Schirmer's test Without Paracein				
Right eye	35 (25)	35 (27)	35 (20)	25 (29)
Left eye	35 (35)	35 (27)	35 (30)	35 (34)
Schirmer's test With Paracein				
Right eye	35 (28)	35 (30)	35 (25)	35 (30)
Left eye	30 (30)	30 (30)	35 (33)	35 (33)
TBUT right eye	11 (8)	11 (9)	12 (8)	12 (8)
TBUT left eye	11 (11)	10 (9)	11 (10)	12 (9)

Table 3: PRE and POST activity values of tear film parameters.

Discussion

There were significant differences between the binocular vision parameters among the READERS and GAMERS. The near point of convergence (Break & recovery) with the accommodative target and red-green filter was decreased by 1cm after both tasks. The results were similar to the previous study, which involved continuous gaming for 4hrs on a computer [10] versus reading tasks with laptop monitors and smartphones. There was an observation that a more remote NPC in smartphones compared to desktops after sustained reading. Though there was statistical significance observation with fusional amplitudes post activity in both groups, the difference is not clinically significant. Even in the earlier studies, no specific pattern of change was observed in positive and negative fusional aplitudes [21].

This study reduced monocular and binocular accommodative amplitudes by 1.25–2.25D following the reading and gaming activity. There was the observation of similar results in a previous study where it reported a 1cm reduction in NPA with continuous gaming for 4hrs. There was an indication of a reduction of about 1.17D after using digital devices for just 30 minutes. The accommodative facility had reduced by 2cpm post-activity (gaming and reading) in monoculars and binoculars. There was a drop in the vergence facility by 2 CPM following the activities. The results followed a previous study with a reduction of around 2 CPM in both accommodative and vergence facilities. A study by Mijung Park stated that most changes in accommodative function had increased after smartphone use [22]. Desktop computer screens comparatively have a bigger screen space occupying the entire horizontal palpebral

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fissure used for viewing [23]. However, smartphones have a relatively lesser screen size. However, the activity performed here in multiplayer gaming involves excessive attention to detail which might significantly drop the number of blinks between the activity, causing an increase in the evaporative dry eye.

Post value–Pre value	Readers	Gamers
	Median (25th, 75th percentile)	Median (25th, 75th percentile)
AC_A ratio	0 (0,0)	0 (0,0)
NPC with the accommodative target (cm)		
Break	1.00 (1,2)	1.00 (0, 2)
Recovery	1.00 (0.50, 1.50)	1.00 (0, 2)
NPC with RG filter (cm)		
Break	1 (1.00, 1.50)	1 (0, 1)
Recovery	1 (0.50, 1.50)	1 (0, 1.50)
AOA in right eye (D)	-2.31 (-4.16, -0.91)	-1.78 (-3.17, 0.95)
AOA in left eye (D)	-2.02 (-3.31, -0.83)	-1.28 (-3.33, 1.11)
AOA in both eye (D)	-0.76 (-3.33, 0.00)	-1.10 (-3.81, 0.74)
NRA (D)	0 (0, 0)	0 (0.0)
PRA (D)	0 (0, 0)	0 (0.0)
MEM right eye (D)	0 (0, 0)	0 (0.0)
MEM left eye (D)	0 (0, 0)	0 (0.0)
AF right eye (cpm)	-2 (-2.50, -1.00)	-2 (-3, -1.50)
AF left eye (cpm)	-2.00 (-3.50, -1.00)	-2 (-4, -1)
AF both eye	-2.50 (-3.50, -0.50)	-2 (-3, -1)
Distance NFV (PD)		
Blur	0 (0, 0)	0 (0,0)
Break	2 (0, 4)	2 (-2, 4)
Recovery	2 (0, 4)	2 (-2, 4)
Near NFV (PD)		
Blur	0 (0, 0)	0 (0, 0)
Break	2 (-4, 4)	2 (-2, 4)
Recovery	2(0, 4)	2 (-2, 4)
Distance PFV (PD)		
Blur	0 (0, 0)	0 (0, 0)
Break	5 (0, 13)	5 (0, 9)
Recovery	2 (0,10)	5 (0, 8)
Near PFV (PD)		
Blur	0 (0,0)	0 (0, 0)
Break	5 (0, 10)	5 (0, 14)
Recovery	4 (0, 7)	4 (0, 5)
Near Vergence facility (cpm)	-2 (-3, -1)	-2 (-3, -1)
Schirmer's without paracein_OD	0 (0,0)	0 (0, 0)
Schirmer's without paracein_OS	0 (0,-1)	0 (0, 0)
Schirmer's with paracein_OD	0 (0,0)	0 (-2, 0)
Schirmer's with paracein_OS	0 (0,-1)	0 (-2, 0)
TBUT_OD	0 (0,-1)	0 (-1, 1)
TBUT_OS	0 (0,-1)	-1 (-1, 0)

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Table 4: Differences between post and pre-activity values among the READERS and GAMERS. NPC–Near point of convergence, R/G filter–Red and green filter, AOA–Amplitude of accommodation, NRA–Negative relative accommodation, PRA–Positive relative accommodation, NFV–Negative fusional vergence, PFV–Positive fusional vergence, TBUT–tear break up time.

In this study, there was no significant difference in Schirmer's test with and without paracain and TBUT. Schirmer's test was performed, which assessed the tear volume, and TBUT to assess tear stability. There was no difference in basal and reflex tears after our continuous reading and gaming sessions. At the end of the session, the gamers reported symptoms of physical discomfort like ocular pain, brow ache, and frontal headache more than the readers' group. A study reported a higher prevalence of ocular symptoms in groups exposed to smartphones [24]. Though the symptoms post activities were not scored, they were interviewed verbally on their physical discomfort post activity. In this study, the accommodative parameters seem to undergo major change compared to vergence parameters. A significant change was noted in the NPA, monocular, and binocular accommodative facility. The difference in the near point of accommodation (2cm) was more significant than the near point of convergence (1cm). The monocular accommodative amplitudes were much reduced (2D) compared to binocular accommodative amplitudes (1D), which provides evidence that accommodation is affected more than vergence parameters. The static measures of accommodation seemed to have less or no change compared to the dynamic accommodative parameters. This constant conflict between the accommodation and binocular vision parameters can lead to binocular vision anomalies when these activities are performed for a prolonged time. A recent study said that reading in a supine position; the gravitational pull increases the amplitude of accommodation when the eye looks from downward to upward [25]. Also, the accommodation affects the IOP, and IOP increases by 2-4 mmHg with posture. Individuals who use digital devices for a long time maintain improper posture and ergonomics, which could lead to diverse eye problems [26,27]. Don Ju Kim et al. reported that the prevalence of dry eye is more in smartphone users when compared with the general population [28]. Also, the blink rate during computer works significantly decreased [29]. The GAMERS screen is more engaging than the READERS screen because of the difference in activity, details, and involvement one would have while gaming, which can lead to worsened signs of fatigue. However, such a difference was not observed between the groups. The differences between the groups in pre- and post-activity Schirmer's values were similar. READERS and GAMERS exerted similar changes in vergence and accommodative parameters pre- and post-activity. Nevertheless, compared to READERS, the GAMERS activity is more addictive, which could accelerate the problems when a GAMER is going to perform the activity for an extended time. Hence, the addictive nature of the activity needs to be considered when providing and planning a treatment strategy. The study was performed on a group of average performing two different activities. The nature of the activity might have influenced it when performed on people with different non-strabismic binocular vision anomalies. The previous study on the effect of near work on binocular vision anomalies reported that CI

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has significant changes in all the parameters post-activity compared to the group of normal subjects [29]. Hence this needs to be further assessed by enrolling different NSBVA categories into the study.

Conclusion

Continuous gaming and reading show significant changes in vergence and accommodative parameters. However, there no difference noted in the magnitude of change between the readers and gamers. Having said that, the addictive nature of gaming can lead to worsened symptoms and signs when not being used in a controlled period.

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Citation: Yogalakshmi SBK, Anand M, Gupta D. Effects of Continuous Online Multiplayer Gaming on Ocular Health. J Opto Ophth. 2022; 3(1):1-10.
DOI: https://doi.org/10.37191/Mapsci-JOO-3(1)-021