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THE IMPACT OF VIDEO GAMES ON PHOTOSENSITIVE EPILEPSY IN CHILDREN AND ADOLESCENTS – A LITERATURE REVIEW

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ABSTRACT

Introduction and Aim: This narrative review aims to assess the potential risks of video games in triggering photosensitive epilepsy (VGA) in children and adolescents, with particular focus on the most significant visual risk factors and evidence-based preventive strategies.

Content of the Review: A comprehensive review of literature indexed in the PubMed (Medline) database between 1990 and 2024 was conducted. The review discusses the clinical history and neurophysiological mechanisms of video game-related seizures, the impact of visual stimuli (e.g., flashing lights between 3-50 Hz, high-contrast colors, full-screen effects), and risk variability in pediatric populations.

Conclusions: Video games may provoke epileptic seizures in children and adolescents with photosensitive or photogenic epilepsy. Awareness of the primary visual triggers and adherence to prevention guidelines can significantly reduce seizure risk during gameplay.

Keywords: Video games, Epilepsy, Photosensitive epilepsy, Photoparoxysmal response, Photosensitivity, Seizures, Video-game epilepsy (VGE), Video game-related seizures (VGRS)

INTRODUCTION

Since the early 1980s, video games have become a popular form of entertainment for millions worldwide, particularly among children and adolescents. They have evolved into a cultural phenomenon, much like literature or cinema before them. Widely accessible and mass-produced, video games are now an integral part of youth lifestyles and emerging trends [4]. While they offer fun, education, and social interaction, they also pose health risks. One lesser-known but serious concern is the potential impact of video games on individuals with photosensitive epilepsy-a form of epilepsy triggered by visual stimuli. Even individuals not previously diagnosed with epilepsy may experience seizures if they are photosensitive, which is defined as an abnormal EEG response to visual stimuli, known as a photoparoxysmal response [22].

As early as the 1990s, with the growing popularity of Nintendo games, reports emerged of seizures occurring among young players, suggesting a new trigger for photosensitive epilepsy. This condition-also called light-sensitive epilepsy-is a specific type of epilepsy where seizures are triggered by certain visual stimuli, most often flashing lights or contrasting geometric patterns. Although most common in children and adolescents, it can also affect adults[28]. Approximately 3-5% of people with epilepsy have the photosensitive form, while in the general population, susceptibility may occur in 1 out of every 4,000 individuals [7]. While about half of those with photosensitivity react to flashing lights up to 50 Hz, seizures have also been reported in individuals without previously known photosensitivity when playing video games [19, 31].

Initially dubbed "space-invader epilepsy" or "Nintendo epilepsy," the condition eventually came to be known as video-game epilepsy (VGA), a term still in use today [7].

Fast-paced video games with intense visual effects, rapidly changing images, flashes, and explosions have always been strong seizure triggers for those with photosensitive epilepsy. The main risk factors include: flashing lights with frequencies between 3 and 50 Hz, high-contrast color combinations (e.g., red on blue or bright colors on dark backgrounds), and full-screen visual effects that engage the entire visual field the more visual field involved, the higher the neurological response risk [15, 21].

To mitigate these risks, video game companies have implemented safety measures, such as seizure warnings before gameplay, frame rate regulations to avoid dangerous frequencies, and graphic effect settings that allow players to reduce brightness, contrast, or disable certain effects.

Individuals with photosensitive epilepsy are advised to take extra precautions if they wish to play video games, including:

- Choosing visually low-intensity games and avoiding those with flashing effects, fast-paced action, VR, or strobe horror scenes;
- Using smaller screens (e.g., 12-inch monitors) or screens with higher refresh rates (100 Hz);
- Adjusting screen settings and playing in well-lit environments (as darkness intensifies flashing effects);
- Taking regular breaks (every 30–60 minutes);
- Wearing polarized glasses and monitoring for warning signs (nausea, headaches, dizziness, visual disturbances) that may signal an impending seizure [17].

While several studies have addressed the relationship between visual stimuli and seizure induction, few have focused specifically on the effects of modern video games in pediatric populations. Existing literature often lacks detailed analysis of preventive strategies, real-world exposure factors, and variability in individual susceptibility. Moreover, the growing complexity of visual content in video games, including the use of virtual reality and stroboscopic effects, calls for an updated review. This gap in the literature highlights the need for a focused synthesis of evidence targeting video game-related photosensitive epilepsy in children and adolescents.

AIM

This narrative review aims to synthesize current evidence on video game-related photosensitive epilepsy in children and adolescents, with a focus on mechanisms, seizure triggers, risk factors, and preventive strategies.

METHODS

This article is a narrative review based on literature published between 1990 and April 2024. A structured search was performed in the PubMed (Medline) and Google Scholar databases. The following search terms were used in various combinations: "video games," "epilepsy," "photosensitive epilepsy," "photoparoxysmal response," "photosensitivity," "seizures," "video-game epilepsy (VGE)," and "video game-related seizures (VGRS)." Boolean operators (AND, OR) were applied to refine search results.

Priority was given to high-quality reviews and large clinical or observational studies. In total, 37 articles were selected for detailed qualitative analysis.

RESULTS AND DISCUSSION

Photosensitive epilepsy is a type of epilepsy where quickly changing visual stimuli act as a trigger. Photosensitivity arises when the retina is exposed to rapidly shifting lights or geometric patterns, leading to abnormal brain responses. This condition affects around 3% of the population but may also affect individuals without prior epilepsy diagnoses, especially when exposed to rapid color changes, geometric shapes, or bright flickers with sudden changes in luminance [17].

The first recorded game-triggered seizure occurred in 1981 in a boy playing *Astro Fighter*. In the 1980s, viewers of the U.S. TV show *Captain Powers* also experienced seizures. A notable case in 1992 involved a 14-year-old boy in the UK who died while playing a Nintendo game. Other cases include a 1993 TV ad for "Pot Noodle" and widespread seizures from a 1997 Pokémon episode in Japan, which affected 685 children due to a 4-second red-and-blue strobing sequence at 12.5 Hz [12, 9].

The term "space-invader epilepsy" was first coined by Rushton in *The Lancet* (1981). Other labels included "Nintendo epilepsy" and "electronic screen games epilepsy (ESGE)", but today the term "video game epilepsy (VGE)" is standard. The Epilepsy Foundation issued the first VGA prevention guidelines in 2005, followed by a 2006 report listing games likely to trigger seizures [5].

VGA is primarily associated with photosensitive epilepsy and light sensitivity, leading to neurological symptoms such as headaches, dizziness, nausea, disorientation, and seizures typically tonic-clonic, myoclonic, or focal (especially occipital or temporal) [7]. Numerous studies confirm the link between VGA and photosensitivity, including large-scale European research by Kasteleijn-Nolst Trenité et. al. [15], who compared 387 participants watching neutral TV programs vs. playing *Super Mario World*. The game proved a significantly stronger photosensitivity trigger, especially on 50 Hz screens. Further studies confirmed *Super Mario World* was more epileptogenic than even flashing-light TV broadcasts [14].

Table 1 summarizes key visual stimuli known to provoke video game–related seizures in photosensitive individuals. Notably, flashes between 15–20 Hz, bright light over 20 cd/m², and high-contrast geometric images (e.g., red on blue) are considered the most epileptogenic. Early recognition of such triggers is essential for developing safety guidelines and preventive recommendations.

Table 1. Major risk factors for triggering VGA-type epileptic seizures

Risk Factor	Description
Flashing lights	Flashes with a frequency of 3 to 50 Hz, especially 15–20 Hz
Luminance intensity	Flashes brighter than 20 candelas/m²
Color contrast	Intense color contrast, such as red on a blue background
Full-screen visual effects	Effects occupying at least 10–25% of the field of view
Geometric patterns	Changing stripes or other specific patterns

Source: Photic- and Pattern-induced Seizures: Expert Consensus of the Epilepsy Foundation of America Working Group. Epilepsia. 2005;46(9):1423–1425.

Particularly, flashes between 15–20 Hz, bright light over 20 cd/m², and high-contrast geometric images (e.g., red on blue) are considered the most epileptogenic. Early recognition of such triggers is essential for developing safety guidelines and preventive recommendations.

Risk factors include screen flicker frequency (100 Hz safer than 50 Hz), viewing distance (1 meter safer than 0.5 meters), and specific visual patterns. French research on 115 epilepsy patients showed VGA does not affect those with non-photosensitive epilepsy [1] Similar findings came from Inoue et. al. [13].

Fisher’s 2021 study on 743 healthy children aged 1-15 found 8.3% showed photosensitivity. Rates were higher in boys and in children over 10 [7]. Rathore et al. estimated light sensitivity in 0.3-8% of healthy individuals and 0.6-30% of those with epilepsy [24]. Despite girls being more light-sensitive, boys experience more VGA-related seizures-likely due to game preferences [29].

As illustrated in Chart 1, of 163 people in a European study with VGA seizures, 85% were light-sensitive, 44% sensitive to patterns, 59% to 50 Hz screens, and 29% to 100 Hz screens [14].

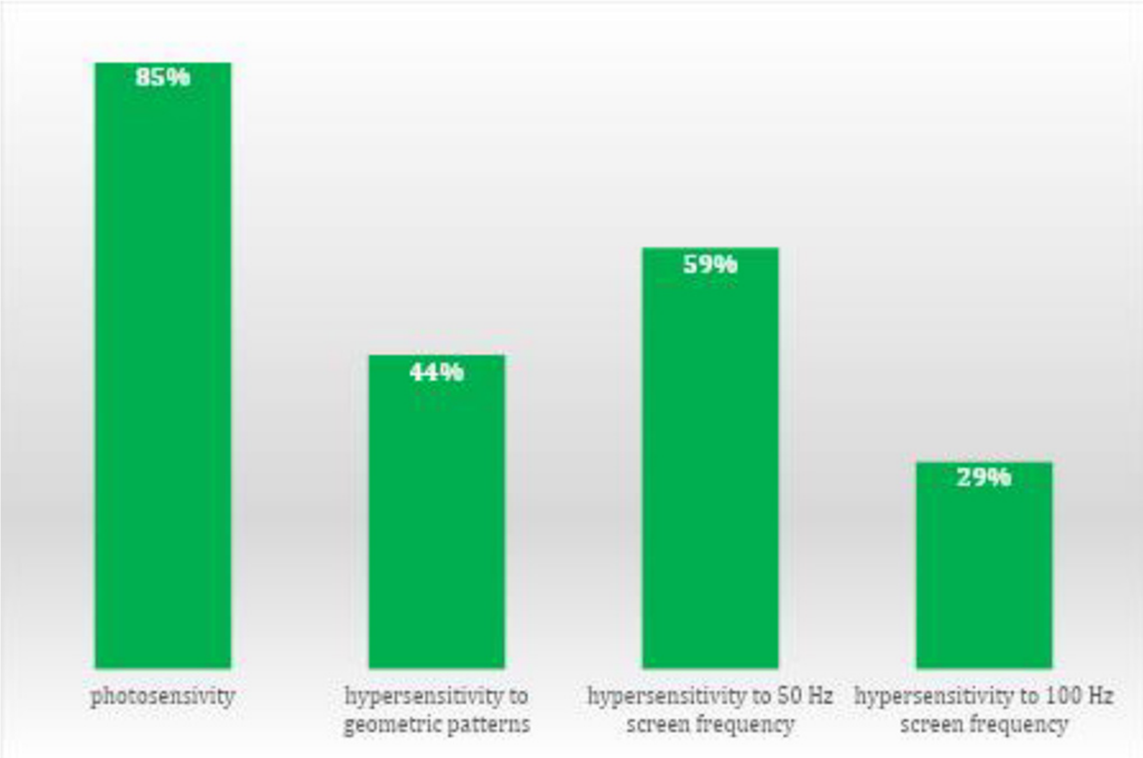

Chart 1. Causes of induced VGA-type epileptic seizures
Source: Kasteleijn-Nolst Trenité, D. G. A., Martins da Silva, A., Ricci, S., Rubboli, G., Tassinari, C. A., Lopes, J., Bettencourt, M., Oosting, J., & Segers, J. P (2002). Video games are exciting: A European study of video game-induced seizures and epilepsy. Epileptic Disorders, 4(2), 121–128.

Across studies, three main visual triggers consistently appear: flashing lights, rapid color changes, and specific geometric patterns [7]. EEG studies confirm this, especially with alternating bright/dark patterns and fast scene transitions [16, 8].

Scientists differ in their opinions as to which elements accompanying computer games pose the greatest risk for triggering video game-related epileptic seizures (VGA). Some researchers, such as Parra et al., emphasize the fundamental role of color in video sequences, drawing on analyses of the original scene from the *Pokémon* TV series, which in 1997 caused a series of seizures among viewers [20]. It has been found that red light flashes are more likely to elicit a photoparoxysmal response than other colors, and that color sensitivity occurs more frequently than sensitivity to white light especially at lower frequencies [6].

Other scientists focus on the significance of flashing frequency, considering it the most critical component [25]. However, more recent studies conducted in part on behalf of the Epilepsy Foundation of America-indicate that the combination of factors poses the highest risk. According to Fisher, the most hazardous stimuli involve flashes brighter than 20 candelas/m², presented at a frequency of 3-60 Hz (especially 15–20 Hz), covering at least 10–25% of the viewer's field of vision. This includes red flashes or alternating striped patterns [6, 7].

As early as 1993, the United Kingdom introduced the first guidelines aimed at preventing game-induced epilepsy. These recommendations included:

1. using screens no larger than 12 inches in diameter, or maintaining a distance of more than four times the screen's diameter if using larger monitors;
2. limiting gaming sessions to less than one hour;
3. undergoing EEG testing with photic stimulation if there is a personal or family history of epilepsy;
4. informing photosensitive individuals about potential risks [2].

Similar recommendations were developed in France, emphasizing a distance of at least 2 meters from the screen and reducing risk by using monitors with a refresh rate of 100 Hz [4].

As a preventive measure, in 2012-based on recommendations from organizations such as the Epilepsy Foundation guidelines for video game developers were introduced to reduce risk factors, not only concerning VGA but also other potential health hazards related to gaming. These are still available at [10]. Safety measures include warning messages about the possibility of seizures (displayed before gameplay), regulations on flickering frequency and the elimination of dangerous ranges, as well as the option to reduce the intensity of visual effects. A notable example is the case of the Polish game studio CD Projekt Red, which in 2020 released the game *Cyberpunk 2077*. It turned out that one of the animations could trigger photosensitive seizures. The studio issued an official warning and later modified the animation to minimize the VGA risk [11].

Both the Epilepsy Foundation's recommendations and numerous VGA-related publications emphasize the use of high-refresh-rate screens (100 Hz), plasma or LCD screens, and proper screen positioning-for example, playing in well-lit environments (as darkness enhances flashing effects), maintaining a distance of around two meters from the screen, and taking breaks of at least one hour (regular breaks every 30–60 minutes help reduce visual strain). Further recommendations include limiting gameplay to a maximum of five hours per day. For individuals with photosensitive epilepsy, polarized glasses and attention to warning signs of an impending seizure are also advised. Common-sense precautions include avoiding graphics with flashing lights, rapidly changing colors, and full-screen effects that occupy more than 25% of the visual field [15, 31,17,7].

Table 2. Preventive recommendations that can prevent the onset of VGA-type epileptic seizures:

Preventive recommendations that can prevent the onset of VGA-type epileptic seizures:
• use of screens with a frequency of 100 Hz, plasma or liquid crystal screens
• distance from the screen ≤2 meters or further than four times the screen diameter
• warnings about the possibility of seizures by computer game manufacturers
• adjusting the screen setting, such as playing in brighter light
• use of at least one-hour breaks in the playing
• avoid graphics with flashing lights, rapidly changing colors and full-screen visual effects

Table 2 presents preventive strategies that were derived from clinical guidelines and expert consensus on photosensitive epilepsy. They aim to minimize the risk of VGA-type seizures in vulnerable individuals, particularly children and adolescents.

Table 2. Preventive recommendations that can reduce the risk of VGA-type epileptic seizures

Recommendation Area	**Details**
Screen technology	Use screens with a frequency of 100 Hz or more; prefer plasma or liquid crystal displays
Viewing distance	Stay at least 2 meters away or more than four times the screen diameter
Manufacturer responsibility	Include seizure warnings with computer games
Lighting conditions	Play in well-lit environments to reduce visual contrast
Breaks and timing	Take at least one-hour breaks between gaming sessions
Visual content design	Avoid exposure to flashing lights, rapidly changing colors, and full-screen effects

Source: Photic- and Pattern-induced Seizures: Expert Consensus of the Epilepsy Foundation of America Working Group. Epilepsia. 2005;46(9):1423–1425

CONCLUSIONS AND FUTURE DIRECTIONS

Video game-related seizures, particularly in children and adolescents with photosensitive epilepsy, represent a significant and preventable health concern. Multiple clinical cases and epidemiological studies confirm that intense visual stimuli-such as rapidly flashing lights, high-contrast color patterns, and immersive full-screen effects-are the principal triggers for video game-associated seizures (VGA/VGRS). Although the exact prevalence remains difficult to estimate, the risk is especially pronounced in individuals with an underlying photoparoxysmal response.

This narrative review highlights that while some neurophysiological mechanisms of VGA have been elucidated, such as the role of occipital cortex hyperexcitability, many aspects remain insufficiently understood. The reviewed literature also reveals a lack of standardization in the diagnostic criteria and risk stratification methods for photosensitive responses induced by video games.

Despite the availability of international preventive guidelines and technical recommendations, their implementation across gaming platforms remains inconsistent. Educational efforts aimed at healthcare professionals, parents, and game developers are essential to improve awareness and minimize risk.

Further research is needed to evaluate the impact of emerging technologies such as virtual reality, high-frame-rate displays, and adaptive lighting environments on photosensitive populations. Prospective studies with standardized EEG protocols and real-world exposure scenarios are crucial to better understand, detect, and prevent VGA-related incidents in vulnerable individuals.

AUTHORS’ CONTRIBUTIONS

- Conceptualization: Jakub Rafalski
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- Literature review and analysis: Zuzanna Gliniecka, Julia Podgórska
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- Visualization: Kornelia Kustra

All authors have read and agreed to the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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