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Topical Review: Optometric Considerations in Sports vs. E-Sports

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Abstract:	Electronic sports (e-sports) have emerged and become a rapidly growing industry. It is a form of competition using videogames, which requires the gamer to spend many hours in front of a display. Due to the nature of this new modality, there are important considerations with regard to ocular health, and visual and perceptual function compared to traditional sports. In general, sports performance is associated with open spaces, gross motor movement, and balance, while electronic sports gamers require visual and attentional stamina at near distances with fine motor control. From an optometric point of view, visual perception is specific to the sports modality as well as the environment where it takes place. In this topical review, we review some optometric aspects to take into account in esports. Issues of screen time and digital eyestrain, visual skill demands, and perceptual cognitive skills such as visual attention are examined in relation to clinical practice. A review of training considerations for traditional sports is compared to training in gaming platforms, with recommendations for future research in this growing modality. The goal of this review is to raise awareness of the various elements to consider when providing vision care to these patients.

INTRODUCTION

It is commonly accepted that, in general, sporting performance requires perceptual-cognitive skills superior to those of the sedentary population (Erickson, 2007). Overall, sports performance is associated with open spaces, gross motor movement, cortical processing of various sensory and motor elements and a high level of decision-making accuracy and precise action execution (Miller & Clapp, 2011). From an optometric point of view, visual skills such as visual acuity, contrast sensitivity, depth perception, peripheral vision, oculomotor skills, dynamic visual acuity and visual-motor reaction are relevant (Ciuffreda & Wang, 2004; Erickson, 2007).When considering the different sporting modalities separately, it is suggested that they involve diverse visual, perceptual and cognitive abilities according to the characteristics of the sports and the position roles (Schumacher et al., 2018; Williams & Davids,1998; Yongtawee & Woo, 2017), as well as the environment where they take place (Yilmaz & Polat, 2018).

Recently, a new sport modality has emerged and has become a rapidly growing industry. E-sports (electronic sports) include organized video game competitions between individuals or teams at the amateur or professional level. Video games are classified into genres according to their content and cognitive abilities required to get through the game. Among the video game genres are action, adventure, sports, real-time strategy, life simulation, music games, and others such as Multiplayer Online Battle Arena and Multiplayer Role Playing Games. Each genre has different aspects in terms of game environment (real-life simulation, science-fiction, etc.) or game platform (jumping, shooting or strategic planning), and most of the games in e-sports require team-coordination strategy with other players in order to win. For instance, Multiplayer Online Battle Arena is based on real-time strategy and action in the same battlefield for all gamers. Multiplayer Role Playing Games are very similar with real-time strategy, but it requires other tasks as the players acquire experience, items or tasks throughout the game. E-sports competitions can include videogames such as League of Legends (Multiplayer Online Battle Arena), Counter Strike (action) or Rocket Team (sports).

There are notable differences when comparing e-sports to conventional sports in many aspects, particularly with regard to visual needs and eye health. The industry of e-sports has become a new form of competition and entertainment, as we can see with the number of recreational and competitive players. For instance, in 2019 there were an estimated 2.471 million users worldwide and this figure is expected to increase every year (site web: statista, 2020). One of the reasons is the possibility of using smartphones instead of computer monitors or televisions, thereby increasing the screen-time exposure.

The ubiquity of video games in today's society has led to a growth in research on their impact on our eyes and visual system (Cardona et al., 2011; Li et al., 2009; Vedamurthy et al., 2015). One of the first concerns using videogames is the elevated screen-time exposure. Some studies have shown an increase of eye symptoms while looking at the digital screens characterized as digital eyestrain (Chu et al., 2011). E-sports have turned into far more than a new form of entertainment, and their gamers spend a great deal of time in front of screens, so much so that their visual health is now a cause for concern. Interestingly, despite the effect on the ocular surface from the exposure of digital screens, there is growing evidence that playing action video games has some benefits in the visual cognitive system, specifically visual attention resources (Feng et al., 2007; Green & Bavelier, 2006).

In this topical review, we wish to compare, from an optometric point of view, the performance of traditional sports versus e-sports. We want to emphasize the possible differences in ocular and visual function related to the practice of each modality in order to understand and manage the possible problems that may be encountered in clinical practice. Our ultimate goal is, however, to raise awareness of the various elements to consider when providing vision care to these patients with a relatively new type of visual performance demand.

OCULAR SURFACE AND TEAR FILM

As mentioned, e-sports involve significant screen-time exposure and allocation of visual attention. Increasing the demands of visual attention or any cognitive function leads to a reduction in blink rate, and could lead to increased dry eye symptoms. Indeed, a common gaming phrase being: *if you blink, you die*. One study compared two groups of players (one non-action video game and a second action video game) and observed that the latter had a decreased blink rate compared to the first group (Cardona et al., 2011). In addition, the increased demands of extended screen-exposure are associated with visual fatigue, especially when using LED-based devices (Benedetto et al., 2014). The type of display is also important since curved screens seem to be a better choice than flat ones for extended users to decrease visual fatigue (Park et al., 2017), and better digital screen resolution is recommended (Siegenthaler et al. 2012). Another study showed an increase in incomplete blinks while using electronic devices such as tablets and computer monitors after 6 minutes of screen-exposure, which could exacerbate the symptoms of visual fatigue (Argilés et al., 2015). Interestingly, some authors have also documented that incomplete blinking, rather than a decrease in spontaneous eye blink rate (SEBR), could be the main contributory factor of dry eye symptoms and visual fatigue (Portello et al., 2013). Thus, screen-exposure and symptoms of dry eye while playing videogames are important factors to be taken into account.

Another important aspect about e-sports is the possibility to play in a virtual reality (VR) headset. Few studies have investigated the possible modifications in tear film and meibomian gland function with long-term virtual reality headset use. On study found a modest improvement in lipid layer thickness and tear film stability after 40 minutes wearing a virtual reality headset (Turnbull et al., 2019). Further research using virtual reality headset within the framework of e-sports is required to assess possible alterations in the ocular surface and tear film.

A thorough examination of the ocular surface, tear film and blinking patterns may be advantageous to address symptoms of visual fatigue. More studies of the causes and treatments for visual symptoms in these populations are needed to clarify this subject.

In contrast, regular practice of many sports (such as tennis, athletics, swimming and modern pentathlon) may have an insignificant effect on the quality and quantity of tears. However, it has been proved that, in general, one hour of sports training significantly deteriorates tear film depending on the sports modality, environmental conditions and the various factors involved in training, particularly body dehydration and visual effort (Quevedo et al., 2000).

LOWER LEVEL VISUAL FUNCTIONS

The visual performance demands can vary tremendously between traditional sports and e-sports. E-sports competitions require a large amount of time in front of a screen, with heightened attention and concentration at short distances. Many games require control and precision of mouse landing and clicking in conjunction with keyboard typing. Due to this nature, it seems appropriate to evaluate accommodation and vergence skills that measure factors affecting sustained task performance. A thorough assessment of accommodation could include measures of accommodative amplitude, negative/positive relative accommodation, near dynamic retinoscopy and accommodative facility (Rosenfield, 2011). The screen dimensions delimit peripheral vision in e-sports since all the space outside the screen is irrelevant. This is a big difference in comparison with sports like soccer, basketball or tennis, for instance. Similarly, eye movement demands on saccades and pursuits are limited to the area inside the screen. For example, if a gamer is sitting at a distance of 60 cm from a 27” screen, the maximum extent of saccades are between 53º of visual angle. It does appear that fixation duration could play a role in e-sports performance skills, as it seems that skilled gamers have more variability, taking more short fixations and more long fixations compared with amateur players (Velichkovsky et al., 2019). Other than fixation duration, to our knowledge there are no studies of saccade or pursuit kinematics, nor other vision skills in professional e-sports players. However, it seems that playing video games regularly could decrease saccadic reaction times and increase the peak of saccadic velocity, leading to more efficiency of saccade control (Mack & Ilg, 2014). In addition, gamers who habitually play action video games modulates saccadic control (West et al., 2013), and induce plasticity in attentional control (Hutchinson et al.2016).

An important difference in traditional sports is that viewing distances are usually much greater than the near demands of competitive gaming, and in many sports the view of the competitive action is frequently interrupted. Most visual performance assessments are conducted at far viewing distances for athletes, whereas assessments at near viewing distances may be more ecologically relevant for competitive gamers. In addition, most sports involve constant body movement and demands on postural balance. Given the inherent time constraints in many sports, athletes must not only retrieve, encode and respond accurately, but also respond in dynamic conditions under severe time pressure. Athletes often face unpredictable paths of key elements with sudden changes in direction and shape, as well as periodic occlusion of the target(s), teammates and opponents (Faubert & Sidebottom, 2012). There is evidence that competitive athletes often have better visual skills than less skilled athletes (Faubert & Sidebottom, 2012; Mann et al., 2007) and nonathletes (Ghasemi et al., 2009; Ishigaki & Miyao, 1993; Kato & Fukuda, 2002; Laby et al., 1996; Zwierko , 2008).

There is a paucity of research comparing visual skill performance between athletes and competitive gamers. One study found that athletes have superior dynamic visual acuity when compared to gamers or control subjects for horizontal motion at 30°/s and random motion 30°/s (Yee, 2017). Since task response times, gaze behaviours and smooth pursuit gains of each group were similar, visual processing differences could explain the superiority in athlete's dynamic visual acuity.

Regarding virtual reality in e-sports, games such as Pavlov VR (an online first-person shooter) or Echo VR (a futuristic zero-gravity game) are VR-based competitive videogames. At this time, there is not widespread popularity in e-sports for using VR. One possible reason for this is the binocular and accommodative conflicts in VR that need to be addressed. Studies have shown a vergence-accommodation conflict in VR headset that leads to a decreasing ability of vergence and accommodative facility after 25 minutes of use (Munsamy et al., 2020), as well as increasing exophoria and reduced AC/A ratio and accommodative response after 20 minutes (Morse & Bai-Chuan, 1999). One study also found an increase of symptoms as dizziness, headache or nausea after 30 minutes of VR videogame play (Mohamed et al., 2019). However, another study did not find a significant change in phoria, amplitude of accommodation, fixation disparity or stereopsis after 40 minutes in VR headset (Turnbull & Phillips, 2017). Despite these conflicting results, it is evident that the VR platform in e-sports is still gaining popularity. Interestingly, the virtual reality environment has been used as a training tool and to investigate perception and action in classical sports (baseball, American football, etc.) (Zaal & Bootsma, 2011).

HIGHER LEVEL VISUAL FUNCTIONS

Expert gamers, specifically top ranked e-sports players, have been shown to have better multiple-object tracking capability (Pylyshyn & Storm, 1988), when compared with amateur players in a game called Multiplayer Online Battle Arena (Ding et al., 2018). Multiplayer Online Battle Arena games, such as League of Legends, require a high level of visual attention to various locations on the screen at the same time (divided attention), and this skill seems to be important to success in the game. It appears that this learning process is linked to brain plasticity, and could improve network attentional resources and sensorimotor functions (Gong et al., 2015). Interestingly, some studies found that high ranking professional players in e-sports (specifically League of Legends) had higher cortical activation of executive areas (Gong et al., 2019; Li et al., 2020). These results suggest that e-sports competition and expertise may induce neural plasticity and increase visual attentional resources, such as multiple-object tracking tasks in Multiplayer Online Battle Arena games. The authors encourage further research to study the specific visual and perceptual skills important to the different e-sports platforms (action first-person shooter, sports games, or Multiplayer Online Battle Arena).

Interestingly, professional athletes have also been found to have better multiple-object tracking scores than amateur athletes and non-athletes (Faubert, 2013), and a study of National Basketball Association players showed that preseason multiple-object tracking motion speed thresholds correlated with positive game statistics (Mangine et al., 2014). Such evidences suggest that multiple-object tracking abilities are fundamental for both athletes and gamers, despite the contextual differences in visual task requirements and environmental settings.

The visual search patterns of experts compared with novices during specific sports demands have been the focus of many studies. The study paradigms typically used attempt to discriminate differences in the number of fixations to determine the amount of information assessed by the observer and differences in the duration of fixations to determine the amount of time expended to collect the visual information from each specific fixation. Most studies have found that experts display less long-duration fixations than novices during the viewing of specific sport situations, particularly when required to move while gaze behaviors are recorded (for a review, see Mann et al, 2007).

In contrast, visual search analysis using photographic or video displays of static subjects has evidenced an opposite trend, namely that experts exhibit more fixations on more peripheral aspects of the action (Mann et al., 2007). Further investigation will be needed to determine if this may be extrapolated to e-sports.

Decades of research in many interceptive sports (e.g., tennis, cricket, baseball) and contact sports (e.g., football, basketball, hockey) confirm that elite athletes frequently display superior perceptual-cognitive skills, such as visual attention, sensorimotor processing speed, anticipation, pattern recognition, and situational awareness (Faubert & Sidebottom, 2012; Morris-Binelli & Müller, 2017). When comparing e-sports and sports players, one study found that gamers demonstrated better executive function as well as spatio-temporal cognitive abilities in comparison to pro-baseball players, who exhibit superior intuitive perception (Kang et al., 2020).

It seems that, in addition to some specific vision and perceptual cognitive skills, the most significant differences between traditional sports and e-sports lie in the motor component (fine motor vs gross motor balance), display limits versus open playing field distances, and controlled indoor versus less controlled outdoor environmental conditions. Furthermore, different types of fatigue should be taken into account; specifically, fatigue is predominantly mental for gamers, and more physical with athletes. In contrast, multiple-object tracking abilities may share similar relevance for both gamers and athletes.

TRAINING PERFORMANCE

An exhaustive literature review revealed a lack of studies for specific visual training programs to improve perceptual-cognitive performance in e-sports. There is growing evidence suggesting that some genres of videogames could improve particular perceptual skills. Action video games are by far the most studied category to improve visual and perceptive functions. Action video games players seem to select and guide visual attention better (Bavelier et al., 2012; Green & Bavelier, 2003), and some studies suggest that they may serve as a good tool to train skills such as visual attention (Belchior et al., 2013), and visual processing speed (Dye et al, 2009). An important factor to improve or modify these abilities through playing videogames is the motivation and desire to play (Kühn et al., 2014), as these factors seem to assist in perceptual learning (Green et al., 2010). More importantly, some studies show that action video games may be used to improve visual perceptive functions such as contrast sensitivity (Li et al., 2009),and visuo-motor coordination (Li et al., 2016), seemingly a promising tool to train visual perceptual skills. In relation to spatial resolution and visual processing, it is also important to note that crowding is reduced by playing action video games (Green & Bavelier, 2007).

However, e-sports are not defined only by Action video games, as there are tournaments in other games like Multi Player Online Battle Arena or sports (soccer, for instance). Therefore, it is important to identify the visual abilities required for each videogame in order to study the factors that could induce perceptual learning through extensive videogame playing.

Perceptual-cognitive training programs offer a possibility of enhancing sporting performance (Krasich et al., 2016; Moreau & Conway, 2013). This type of training has been aided with new digital technologies in general (Appelbaum & Erickson, 2016), and action video games in particular (Broadbent et al., 2015). These platforms offer multiple sensorial modalities that combine different skills by means of representative tasks with decision making situations in simulated environments that recreate progressively growing demands. Training conditions should ideally recreate arousal states, such as high-anxiety (Alder et al., 2016), or fatigue (Casanova et al., 2013), in coherence with the idea of increasing fidelity with the sporting environment. It could also be suggested to add specific physical actions in advanced levels to integrate perceptual and motor response (Farrow, 2013), given the importance of the close functional coupling of perception and action in skill production (Farrow, 1986). These concepts, which are widely accepted for conventional sports, could also be applied to e-sports. Consequently, we would suggest integrated training including not only visual perceptual but also cognitive, psychological and even physical training of involved elements. Based on the available literature the authors highly recommend the development of research studies to determine the effectiveness of training with an action video games platform that includes specific physical, psychological and environmental components important in e-sports performance.

Linked to the idea of purposefully training under suboptimal conditions, strobe training requires athletes to more effectively use limited visual input, potentially leading to increased sensitization and better visual skill development when returning to normal visual conditions. A review by Appelbaum and Erickson (2016) concluded that stroboscopic training leads to enhancement in sensory and motor skills, with some evidence that these improvements translate to on-field performance. The authors further suggest that this type of training could also be applicable to e-sports, and encourage researchers to investigate this possibility.

Clark et al; advocate the theory that applied vision training could not only enhance sports performance, but also help to prevent injury, especially head trauma (Clark et al., 2020). From another point of view, research has revealed that playing some types of action video games can lead to improved recovery from brain trauma (Vakili & Langdon, 2016).

In traditional sports, various studies have suggested that systematic participation involves the development of different visual cognitive skills according to the characteristics of the type of sport and stimulus presentation modality (Burris et al., 2020; Faubert & Sidebottom, 2012), acting as a kind of unplanned and hidden visual training (Quevedo et al., 2011). Future research will indicate if such assertions also apply for professional gamers.

Finally, Virtual Reality simulations provide a unique platform for complex training protocols to promote targeted sports-specific visual and cognitive abilities with a minimal risk for injuries. This type of platform has been shown to lead to transferable and generalized gains, providing a potential added value over computer screen training (Pagé et al., 2019).

OPTOMETRIC MANAGEMENT IN E-SPORTS

As stated previously, an important factor competitive gaming is the increased probability of suffering dry-eye symptoms and eyestrain due to both screen-time exposure and the increase in incomplete blinks. One way to reduce dry-eye symptoms is to follow some ergonomic rules to prevent this problem. Frequent breaks are recommended to release the vergence and accommodative demands. The American Optometric Association suggest the 20/20/20 rule (take a 20-second break to view something 20 feet away every 20 minutes) to alleviate digital eyestrain. However, this classic rule could be difficult to implement in e-sports, due to the time constraints of live tournaments. The use of a protective shield to minimize screen reflection could be helpful to increase blink efficiency and reduce visual fatigue (Tsubota et al., 2002). An appropriate working distance is also important, as some studies have shown that short viewing distances have been related to increased visual strain, with users reporting fewer symptoms of visual fatigue at 100 cm than at 50 cm when font size is adjusted to provide the same visual angle (Jaschinski-Kruza, 1988).

There are nutritional options that are beneficial for eye health and function. Nutrients containing omega-3 fatty acids can reduce dry eye effects (Deinema et al., 2017; Epitropoulos et al., 2016), and other nutrients protect the retina from photo-oxidative damage (lutein, zeaxanthin and beta-carotene) (SanGiovanni et al., 2007, 2013). The protective effects of the nutrients may benefit athletes from accumulated sun exposure over time, and may also benefit e-sports competitors who spend a considerable amount of time gaming. The protective effects of macular pigment density may help with “blue light" exposure from extensive "screen time." Increasing macular pigment density also appears to improve visual and neural performance in healthy, young subjects, which could be a further benefit for gamers (Nolan et al., 2016; Stringham et al., 2017).

Optometrists should also to take into account that gamers typically have much longer screen time compared to office workers. A cross-sectional survey in 7.000 gamers found of an average of 25.86 ± 19.06 hours a week of playing (mean age 31.16 ± 9.65 years old), without counting other screen time daily tasks (watching TV or working) (Williams et al., 2008).

In summary, we recommend the following visual and ergonomic factors be assessed with these patients:

1) Ocular surface and tear film
2) Vergence function (phoria, associated phoria, ranges and facility)
3) Accommodative function (amplitude, posture, relative accommodation and facility)
4) Ergonomic factors (screen reflections (Tsubota et al., 2002), type of display, posture, viewing distance).

In addition, it could be interesting to develop specific visual perceptual training to increase visual processing speed, eye hand movement, specific peripheral awareness, divided attention and visual memory to enhance performance in e-sports competition. Currently e-sports professional teams have a coach, psychologist and even nutritionist or physiotherapist to improve their overall health as well their gaming performance. In addition, it could be interesting to develop specific visual perceptual training to increase visual processing speed, eye hand movement, specific peripheral awareness, divided attention and visual memory to enhance performance in e-sports competition. Also, we believe that an optometric evaluation (vergence-accommodation response) could be beneficial for this highly visual new modality of sport.

CONCLUSIONS

Gamers of all levels are becoming a new challenge for researchers and eye care professionals. Several important considerations should be taken into account with regard to clinical care of active gamers compared with those in traditional sports. First, the increase in screen-time exposure could exacerbate digital eyestrain symptoms and should be assessed to determine effective interventions that both decrease visual symptoms and increase visual performance during gaming. It is also important to consider investigation showing the benefits of an action video game platform to train visual cognitive skills such as visual attention and visual perception. The use of action video games to enhance some of these skills has proven to constitute another line of research in certain fields like amblyopia treatment, and could be interesting as a tool to train visual abilities in e-sports competition. Based on the findings of research focused on traditional sports, the authors suggest investigating the effectiveness of specific and integrative visual perceptual training to improve gamer's performance, as well as the ocular health and visual performance abilities (i.e., eye movements, vergence and accommodation) involved in this new modality of sport. The authors cannot end this topical review without taking into consideration that, with many traditional sports leagues and competitions halted due to the ongoing COVID-19 crisis, it is possible that we could see e-sports leagues grow at an even quicker rate than expected.

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