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Original article

The effects of esports on sleep: a systematic literature review

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Abstract

The purpose of this review is to synthesize all the observational studies that studied the effects of eSports on sleep. In addition, it has systematically brought together all peer-reviewed observational studies related to the sleep of eSports gamers to draw the attention of field academicians and researchers to the issue related to eSports and promote observational studies on future in the field of sports sciences. Playing eSports games or competing in these games can have significant consequences for players' health. As the popularity of eSports continues to grow rapidly around the world, studies focusing on understanding the health risks and benefits associated with eSports competition and participation have been delayed. Sufficient attention has not been paid to the development and evaluation of preventive interventions which address the harms that video games interrelating with eSports can cause. Similarly, there are gaps in the evidence on ways to encourage safe and healthy digital gaming among the ever-growing eSports gamers population. In order to develop evidence-based guidelines and intervention strategies that include sleep and sleep quality, these gaps need to be filled with scientific research.

Keywords: eSports, Sleep, eSports players, Health.

Introduction

Hundreds of millions of players are engaged in virtual and competitive electronic games every day. The interest in traditional sports has decreased with the current Covid-19 pandemic (DiFrancisco-Donoghue et al. 2019). But there has been an increase in the participation in eSports, which allows for socialization and social distancing. It has been stated that eSports athletes can devote 14 hours a day to training and competitions. Players integrate into healthy life programs to improve their performance and extend their careers live (Kemp et al. 2020). Researchers trying to evaluate the use of electronic equipment have determined that eSports can change sleep patterns (Sanz-Milone et al. 2021). In order to continue to control their characters in the game, eSports players must demonstrate highly coordinated movements and develop models. In addition, the most important characteristics of good eSports players are that they have a good memory and attention (Campbell et al. 2018). Currently, eSports around the world has become an area of high interest and practice among adolescents and young adults, just like traditional sports. It is stated that the age range of Chinese eSports players is between the ages of 17 and 28, and the average age is 19. And this suggests that the majority of athletes are young (Sanz-Milone et al. 2021). The recommended average sleep time for the young population is 8-9 hours (Mercer et al. 1998). The literature has shown that sleep has a vital role in learning and memory consolidation, but also that it is the time when one's attention levels are renewed (Fullagar et al. 2015). If a person has a poor sleep quality, there may be a condition that increases the likelihood of injury and accident in both his/her memory and attention (Lowe et al. 2017).

eSports are played on computers, tablets, phones, and television screens that excessively expose players' eyes to light-emitting LEDs. Recent studies show that excessive exposure to the blue light spectrum from LEDs can cause retinal and photoreceptor damage. Excessive exposure affects the natural circadian rhythm. Melatonin is a hormone synthesized in our body, and its role is to regulate the natural circadian rhythm. While the level of melatonin is low during the day, at night its level increases before sleep. To conclude, excessive exposure to LED lights disrupts the circadian rhythm and lowers the level of melatonin (DiFrancisco-Donoghue et al. 2019).

Sleep is a basic bodily function that often does not receive adequate attention. Many researchers point to three main characteristics of health: nutrition, exercise, and sleep (Tremblay et al. 2016). Studies have revealed

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that Olympic athletes sleep 6.5-6.8 hours per night instead of the recommended average of 8 hours of sleep (Vitale et al. 2019; Charest & Grandner, 2020; Lucidi et al. 2007; Swinbourne et al. 2016). Traditional sports typically involve a combination of physical and cognitive abilities. However, eSports is more dependent on cognitive abilities (Bonnar et al. 2019; Staiano et al. 2012).

eSports players need to have a solid visual motor and information processing speeds (Sachse et al. 2013). Players are required to make motor movements quickly in response to rapidly changing information from multiple players and the environment (Castel et al. 2005). They need to process visual information and their on-screen avatars need to respond with fine motor movements. To be able to do this, it is required that the small muscles in the hands move precisely (Hernandez et al. 2013). It is mentioned that sleep deprivation reduces reaction time, speed of processing, and the processing speed of visual information (Cohen-Zion et al. 2016). Thus, a deterioration in visual-motor performance occurs (Lowe et al. 2017). And this circumstance significantly slows down the eSports player and puts them at a competitive disadvantage (Bonnar et al. 2019; Rudolf et al. 2020).

Attention and working memory are important in the cognitive process. Since eSports competitions last more than 40 minutes, attention is required for a long time (Bonnar et al. 2019; Katona et al. 2019; Hodge et al. 2019; Karhulahti, 2020). Selective attention is important to reduce the effect of distractions outside of the game (audience noise) (Fairley & Tyler, 2012; Rojas Ferrer et al. 2020) and to focus on in-game elements (Brown et al. 2020). That is why functioning memory is necessary to manage both short-term and long-term goals (for example, adhering to a predefined attack plan). It is also noted that sleep deprivation reduces the decrease in the performance in working memory with selective and continuous information (Bonnar et al. 2019).

Errors that occur with reduced reaction time and reduced processing speed due to the lack of sleep are short attention delays and impaired tactical awareness (Mousseau, 2004). This situation may be reflected in success or failure at the professional game level (Bonnar et al. 2019).

Lengthening the sleep time refers to increased sleep time. This extension can be by adding a nap to the night's sleep or by prolonging the night's sleep (Walsh et al. 2021; Halson, 2014). In studies conducted on traditional athletes, it has been shown that sleep prolongation has been found to improve the sprint times (Bonnar et al. 2018), tennis service hit (Kirschen et al. 2020), swimming speed (Vitale et al. 2019), and basketball shooting accuracy (Kirschen et al. 2020; Mah et al. 2011). In addition, cognitive performance has been improved. All of these will most likely mean better performance in the game due to reduced errors caused by lack of attention and reduced processing times (Vitale et al. 2019).

It is known that sleep deprivation impairs cognitive function, which can damage eSports players' performance. For this reason, athletes need to prioritize sleep and pay attention to getting enough sleep and prolonging sleep to help their performance at its peak. This study will demonstrate an updated review of the relationship between eSports and sleep behaviors, as advances in eSports in recent years have historically combined with sleep behaviors. Therefore, the purpose of the study is to decisively review the potential relationships between eSports and sleep behaviors by examining recently published observational studies and interventions. Accordingly, the answer to the following questions will be sought:

1. What is the current status of observational evidence (cross-sectional data published between 2016 and 2021) of the relationship between eSports and sleep behaviors?
2. What is the sleep efficiency and sleep quality of the athletes?

Methodology

Therefore, the purpose of the study is to decisively review the potential relationships between eSports and sleep behaviors by examining recently published observational studies and interventions. The surveys have been made starting from 2016, given that competitive games began to appear after video games were played online against other people. The data includes all the studies published between January 2016 and December 2021. The literature review was conducted in the Google Scholar, Science&Direct, PubMed, and Web of Knowledge databases. The following keywords were used in the related search engines. eSport+sleep, eSports+sleep, eathletes+sleep, eSport+healthy, eSport+sleep characteristic, professional esports athletes "sleep". Each and all reviews have been conducted not only in the titles of articles but also in abstracts -in cases where this option is available- for the following reasons: (1) titles can sometimes be limited and may not include the words eSports and sleep behaviors; (2) authors may use a variety of different terms or synonyms corresponding to the concept of eSports and sleep behaviors. Studies conducted on individuals with a chronic disorder (autism) or used a non-observational study design (such as case intervention, qualitative or systematic studies) are not included in this review.

Two authors (AB and PA) independently reviewed the abstracts taken from the first review. The full-text articles of the selected abstracts were evaluated independently by the same authors. Any disagreement on the issue of eligibility after the abstract or full-text process has been resolved by the third author. The reference lists of the included articles have been scanned for eligibility. The data were extracted into a form in terms of study type, population characteristics (age, race, environment, and country), study methodology, eSports, and sleep behaviors.

Results

The selection of the studies is described in detail in Figure 1. 278 articles were identified, including 268 articles from the initial review and 10 articles through the reference lists of the included articles. After 177 articles were removed, 101 original articles were scanned. 52 abstracts were not included in the review since they include chronic disorders (n=17), are interventions or qualitative studies (n=21), and systematic reviews or meta-analyses (n=14). The 41 articles excluded from the scope include evaluations that did not include the concept of sleep (n=19), did not contain eSports and sleep assessment (n=9), and did not involve a relationship between eSports and sleep (n=14). Terminatively, 8 articles were included in the study since they contain the concept we have been scanning.

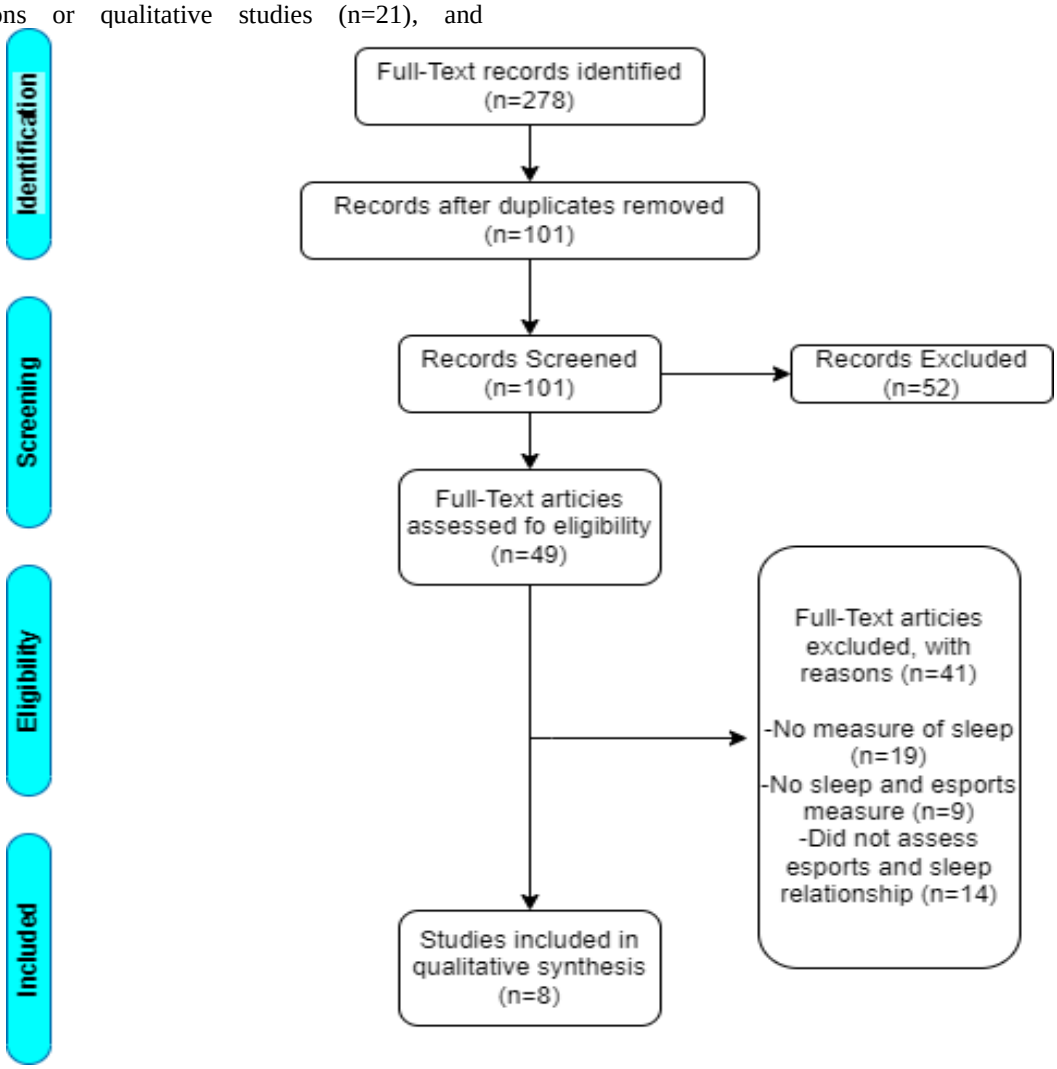


Figure 1. Selection of included research

The descriptive characteristics of the included articles are given in Table 1. The sample sizes of the included studies range from 12 to 1006. Research has been conducted in different countries. The sample age range in the studies ranges from 17 to 25.

Table 1 Descriptive characteristics of included studies (*n = 8*)

	Author, Year, and Country	Sample and Participant	Research Question	Findings
1	Rudolf et al. 2020 Germany	-n=1066 -Age mean: 20 -eSports players	The relationship between eSports players' video game time and their health behaviors	TSD is 7.1 hours. The average screen time is 7.7 hours It has been reported that the quality of sleep is "quite good". Also, it has been reported that the sleep duration of professional eSports players is on average 1 hour more than that of former and amateur eSports players.

2	Lindberg et al. 2020 Denmark	-n=188 -age mean 17,1 -eSports players	The sleep levels of those who have and do not have musculoskeletal pain were studied.	It was noted that 59% of eSports players suffer SD, 26.5% wake up several times a night, 22.2% have sleeping problems during the night, and 93.5% wake up tired from sleep. In addition, it was reported that they slept for 7.4 hours.
3	Altıntaş et al. 2019 France	-n=217 -Age mean: 20 -eSports players	Which variables affect the participants' sleep quality	Players with a high intensity of playing video games and eSPorts have a poorer sleep quality. But no relationship has been observed with respect to screen time.
4	Lee et al. 2021 USA, South Korea, Australia	-n=17 -age mean 20 -Professional eSports Player	Sleep and sleep behaviors of professional eSports players	The TSD of the participants is 6.8 hours. The sleep efficiency is 86.4%. It was determined that the participants had significantly delayed sleep patterns. The average sleep onset was reported as 03:43 and the waking time was reported as 11:29. The average sleep onset time of the participants delayed about 20 minutes, and the average sleep wake-up time was reported as 47.9 minutes.
5	Lee et al. 2020 South Korea	-n=138 -age mean 20.41 -eSports players	Determining the characteristic sleep patterns and risk factors of Korean eSports athletes	The TSD of eSports athletes is 7.26 hours. The average sleep time is 04:04. The average wake-up time is 12:13. The number of awakenings during sleep was set at 1.25. It is noted that eSports players experience a high level of daytime sleepiness. Sleep efficiency was reported as 82.55%.
6	Gomes et. Al. 2021 Brasil	-n=20 -age mean 20.5 -eSports player (LoL)	Characteristics of the sleep-wake cycle in the training and competition routines of eSports athletes	eSports players have a pre-training TSD of 6.40 minutes, and a pre-competition TSD of 6.32 minutes. The pre-training SD is 13.96 minutes and the pre-competition SD is 16.69 minutes. The pre-training SO is 01:38 and the pre-competition SO is 02:17. The pre-training SE is 92.25% and the pre-competition SE is 91.58%. It has been reported that daytime sleepiness levels are high. It is noted that the TSD is low.
7	Vatn, 2021 Norway	-n=27 -Age mean 18.59 -eSports players	How and in what way the characteristics of sleep in eSports athletes and eSports game performances are related to players' sleep?	It has been indicated that the recommended guidelines for TSD of eSports athletes remain at low levels, sleep onset begins later, and sleep balance ends later than in other traditional sports. It has also been indicated that eSports athletes have difficulty falling asleep at night and often wake up from the beginning of sleep to sleep balance. In addition, it has been noted that eSports players with better performance have more sleep duration. The average duration of sleep is 7 hours and 12 minutes. The average sleep delay is 57 minutes. The sleep efficiency is 67%.
8	Sanz-Milone et al. 2021 Brasil	-n=12 -Age mean 17-25 -Professional Esports players	Evaluation of sleep quality of professional eSPorts athletes	In the Counter-Strike: Global Offensive ESPORTS players group, low subjective sleep quality, and high daytime sleepiness were observed. There is poor sleep hygiene, variable sleeping, and waking times between weekdays and weekends. The average sleep delay is 39 minutes, and the sleep efficiency is below 85%.

TSD: Total sleep duration, SD: Sleep delay, SO: Sleep onset, SE: Sleep efficiency

Discussion

eSport players need to have a perfect visual motor and information processing speeds. During the game, the player must form reactions using fine motor skills and small hand muscles to different changes made on the screen by the game or other players. This is of great importance for the athlete's avatar to continue moving toward victory (Bonnar et al. 2019). Sleep

changes can cause sleep restriction, which leads to a decrease in reaction time (Goel, 2017), a decrease in processing speed (Chee, 2015), and slower processing of visual information (Alhola & Polo-Kantola, 2007).

It is noteworthy that the duration of sleep of eSPorts players is lower than that of a healthy adult group (Walch et al. 2016). It has been reported that screen time has negative effects on sleep duration (Carter et al. 2016; Cain et al. 2010) and sleep quality(Carter et al. 2016; Durand et al. 2012)(Rudolf et al. 2020). The literature has shown that the use of light-emitting devices before going to sleep is associated with increased sleep disorders (Grønli et al. 2016; Chang et al. 2015; Gradisar et al. 2013; Cajochen et al. 2011). If there is a very short period of time between media use and sleep time, similar associations may apply to video game use (Rudolf et al. 2020).

It has been reported that video game players with low sleep quality have a worse subjective sleep quality than video game players with high sleep quality (Altınbaş et al. 2019). It also causes a long sleep delay, worse sleep efficiency, a major sleep disorder, and more frequent use of sleeping pills (Dworak et al. 2007; King et al. 2013; Higuchi et al. 2005; Van den Bulck, 2004) The blue light emitted by the video screens is indicated to block the release of melatonin, which is one of the important hormones at the beginning of sleep (van der Lely et al. 2015; van der Maren et al. 2018; Higuchi et al. 2005).

The volume of games is significantly associated with fatigue, insomnia, sleep time, and wake-up time in adults. The more video games individuals play, the higher their reported levels of fatigue and insomnia (Exelmans & Van den Bulck, 2015). Delays in sleep and wake-up time reported in relation to video gaming corroborate research that has shown that media use among individuals coincides with later sleep times (Custers & Van den Bulck, 2012). Also, the more video games individuals play, the more likely they are to need more time to fall asleep, have lower sleep quality and use sleeping pills more often (Exelmans & Van den Bulck, 2015). It has been noted that when video games are played for more than 60 minutes, they will have a negative impact on sleep quality (Dworak et al. 2007; King et al. 2013).

The literature supports the idea of arousal as the basic mechanism between video games and sleep (Cain & Gradisar, 2010; Zimmerman, 2008). Playing video games can affect arousal parameters such as respiratory rate, blood pressure, and heart rate (Anderson & Bushman, 2001). Increased arousal has been associated with difficulties falling asleep and waking up at night (Paawonen et al. 2006; Van den Bulck, 2004). In particular, it has been reported that arousal is even higher for exciting, competitive, and violent video games (Fleming & Rickwood). Despite this, some studies indicate the role of media use in facilitating sleep (Eggermont & Van den Bulck 2006; Gooneratne et al. 2011).The daily use of electronic media devices is associated with sleep complaints in adolescents (Lange et al. 2017). Usually, the recommended amount of sleep for the general population is on average 7-9 hours (Hirshkowitz et al. 2015) and should be less than 9-10 hours for athletes (Watson, 2017). It has been observed that eSports players sleep 6 hours more than athletes of a comparable sports branch, such as chess (Moen et al. 2020). Interestingly, prolonged sleep has been associated with improved athletic performance, such as faster sprint time and reaction time (Mah et al. 2011). On average, eSports athletes are reported to sleep around 2 a.m. and wake up around 10 a.m. (Vatn, 2021). It has been reported that the sleep onset begins later at night and ends later in the morning in eSports athletes (Hrozanova et al. 2018). It is believed that the late sleep onset is caused by playing games for more than one time period. eSports games are played globally. For this reason, games can also be played at night. This situation may explain why sleep starts later at night and ends later in the morning (Vatn, 2021). On average, sleep efficiency among eSports players is at 67% (Vatn, 2021). However, it should be at the recommended 85% level (Ohayon et al. 2017). It is reported that eSports players spend an average of 57 minutes falling asleep (Vatn, 2021). This shows that eSports players struggle a lot to fall asleep. In a systematic study, it has been demonstrated that subjective sleep disturbance is common among athletes (Gupta et al. 2017). In addition, it has been noted that the sleep quality of eSports players is low (Ohayon et al. 2017). There may be several explanations for these findings. First of all, it may be that eSports athletes spend more time on digital devices than other groups of athletes. eSports players reported that they spend an average of 13 hours a day on digital screens. It is believed that eSports players are exposed to a significant amount of light-form digital devices every day, which may have negatively affected their sleep patterns (Green et al, 2017). Indeed, exposure to light from digital screens is associated with a delay in the circadian rhythm system. More specifically, such light exposure, especially late in the evening, is associated with a prolonged delay in the sleep onset (Chang et al. 2015). In addition, research claims that digital media negatively affects the sleep efficiency of adolescents (Fobian et al. 2016). Another possible explanation for the sleep quality is stress. Stress is recognized as a fundamental factor of sleep disturbance (Eliasson ve Vernalis, 2011). It is noted that higher stress levels during the day are associated with higher cognitive and somatic arousal before going to sleep and negatively affect sleep quality. In brief, there is a positive relationship between sleep disturbance and stress (Vatn, 2021).

In conclusion, it has been observed that there are significant individual differences in sleep among eSports players and their sleep patterns are relatively consistent among players. Therefore, the results of current studies show that the characteristics of sleep are individual. In addition, the results provide important

information about how esports players' game performances are related to their subsequent sleep. It is thought that improved eSports gaming performance can be an important tool to improve the sleep of eSports players.

It is well known that sleep restriction impairs cognitive function, which would not be conducive to optimal eSports performance and thus jeopardize the possibility of competitive success. Regarding this, it is thought that due to the unique circumstances and conditions that characterize eSports in a similar way to traditional athletes, eSports players will probably experience a high level of risk of sleep disorders.

It shows that the use of light-emitting devices in the evening can inhibit the secretion of melatonin and, as a result, adversely affect sleep and daytime performance. Given that light-emitting devices are an essential component of eSports, eSports athletes may have a high risk of sleep disorders compared to traditional athletes, especially if training or competitive matches are held in the evening.

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