

The bidirectional impact of internet addiction on sleep quality: A vicious circle?

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Abstract:

Internet addiction (IA) is an emerging disorder that refers to the compulsive need for the internet. IA, particularly prevalent among adolescents, has garnered increasing attention as the internet becomes more pervasive than before. Disrupted sleep quality is a significant concern among the array of detrimental outcomes associated with IA. However, the intricate interplay between IA and sleep quality needs to be more adequately understood, including the potential mediators and the bidirectional relationship between them. This review aims to establish a model to investigate the interaction between IA and sleep quality. The review, to achieve this aim, embarks on a multi-faceted analysis. First, it scrutinizes the neurobiological mechanisms through which IA influences sleep quality. Secondly, it explores the role of specific comorbidities, such as depression and anxiety, as potential mediators mediating the impact of IA on sleep quality. Finally, by summarizing previous studies, this review found a circular correlation between IA and sleep quality. In conclusion, the synthesized findings underscore the intricate connections at play. These revelations collectively highlight the bidirectional and complex nature of the IA-sleep quality relationship. For future research, the establishment of the vicious circle is conducive to the research of new therapies.

Keywords: Sleep quality, Internet addiction, Sleep disorder, Adolescent.

1. Introduction

It is well known that being addicted to substances like alcohol and drug could bring many harmful effects to individuals. Nowadays, due to development of modern technology and the changing of people's lifestyle, internet addiction (IA) have been brought into the view and became a relatively severe problem. Internet addiction does not involve the usage of certain substance. However, it seems to have a similar mechanism like substance addiction. Current research have found a range of possible negative effects of IA, including sleep disorder like insomnia [1]. Lack of sleep usually lead to both physical and psychological stress for the affected individuals, which could severely influence one's life quality. According to papers that investigate the prevalence of IA in adolescence and young adults, 85% of internet users among 466 participants have developed addiction [2]. Thus, it is meaningful to do more

research on the cause and mechanism of internet addiction in order to provide information that helps the development of possible coping strategies. Through the analysis of past academical researches, this review aims to explain the neurological pathways that link internet addiction to sleep disorder. In addition, researchers found that some of the mental disorders, such as depression and anxiety, might act as mediators within relationship between internet addiction and sleep disorder. This would be another focus of this review, as it may give further information of how these two conditions correlates and influences each other.

2. Functional neurologic mechanism and physiological mediation between internet addiction and sleep quality

2.1 .Neurotological basis

Individuals with internet addiction display many charac-

teristics shared with those with low sleep quality, suggesting that internet addiction symptoms may contribute to poor sleep quality. Three potential mechanisms by which this may occur are presented below:

Mechanism 1: Melatonin

Nighttime lighting, associated with the use of electronic devices on which the internet is consumed, has long been shown to be a significant cause of the disruption of melatonin-dependent circadian rhythms, leading to sleep disturbances.

Melanopsin, a photosensitive protein in our retina, has long been shown to drive melatonin levels to entrain our circadian rhythm [3]. Exposure to screens thereby influences melatonin secretion through the action of melanopsin [4]. In their study, demonstrated that using a display in a dark environment decreases melatonin secretion by about 10%, while exposure to a bright setting decreases it by 33.1% [4]. Two demonstrates that exposure to a computer- or cell phone screen at night exerts a profound, abnormal influence on melatonin levels [4].

Melatonin plays a crucial role and is widely employed to treat insomnia [5,6]. It is intricately linked to human circadian rhythms and has a soporific effect, which means a higher level of melatonin makes people more likely to fall asleep [7]. Also, plasma melatonin levels are typically low during the day and elevated at night due to rapid metabolism [8].

However, in cases of internet addiction, individuals might struggle to cease electronic usage at night, and display light will suppress melatonin production, disturbing the body's circadian rhythm and potentially causing sleep difficulties or reduced sleep quality [4].

Mechanism 2: Dopamine

Internet addiction is associated with dysfunction of the dopamine system, and as dopamine involves in wake-promoting, the malfunction may lead to lower sleep quality [9]. In drug addiction, the stimulation of dopamine cells by the drug is much more significant than physiological. Therefore, repeated drug use causes the threshold at which dopamine cells are activated to be raised. Ultimately, and simultaneously with imaging evidence, both dopamine receptors and dopamine release are reduced in addicts [10]. Even though few dopamine receptors have been analyzed in Internet addicts, PET imaging studies have still revealed similarities between Internet addiction and drug addiction mechanisms. In an experiment, dopamine transporter protein (DAT) was imaged in 20 males [11,12]. The results showed that the subjects' striatal DAT levels were greatly lower than those of non-addicted subjects [11,12]. Enhancing dopamine release is effective in promoting arousal, and amphetamine-like compounds and modafinil exert arousal-promoting effects through their interaction

with DAT [13]. Thus, for Internet addicts, a deficiency in dopamine release is likely to result in prolonged sleep.

Mechanism 3: Cortisol

There is a strong link between addiction and stress; individuals with substance or behavioural addictions have higher psychological stress responses [14]. A study of the hypothalamic-pituitary-adrenal (HPA) axis, a critical stress system, found that behavioural addiction was associated with blunted cortisol. Also, patients with Internet addiction did show blunted cortisol responses, pointing to a possible prediction of decreased sleep quality [15, 16].

One of the models used in studying the causes of insomnia is the quality-stress model, which suggests that people with deficits in stress regulation are more likely to experience decreased sleep quality. Low cortisol levels in the morning and at night have also been linked to insomnia problems, and people with a familial risk for insomnia show a blunted cortisol response to stress [17,18]. To summarize, most patients with Internet addiction have blunted cortisol response, and since it is one of the factors contributing to decreased sleep quality, Internet addiction can potentially decrease sleep quality in this way.

2.2 .Moderating factors

There is a direct neurological link between Internet Addiction (IA) and sleep quality. However, in exploring the interaction between IA and sleep quality, we cannot overlook other factors that an individual might present and interact with IA to affect sleep quality. Patients with IA often present accompanied by multiple concurrent disorders, including Attention-Deficit Hyperactivity Disorder (ADHD), depression, substance use disorder, social anxiety disorder, as well as behavioral, anxiety, and mood disorders [19]. IA might even lead to depression and predict anxiety and stress [20,21]. Also, patients with IA often exhibit symptoms of ADHD [22]. This suggests that IA might co-function with other comorbidities. Hence, it's imperative to consider the mechanisms through which these comorbidities might affect sleep quality.

· Depression

Studies have presented that depression can be result of IA, and adolescents who use the internet more frequently demonstrate a heightened level of depression compared to their peers [23]. The brain regions involved in depression include the dorsolateral prefrontal cortex responsible for short-term memory, the anterior cingulate cortex responsible for self-perception, and the lateral orbitofrontal cortex responsible for processing negative emotions. Individuals with depression exhibit enhanced connections within these neural regions, which could lead to an increase in rumination (like pessimistic thinking or repeatedly recalling negative experiences), which is a crucial mechanism

impairing quality of sleep [24]. Given the mixed quality of information on the Internet, individuals with IA might be more exposed and absorb more content. Such overexposure could potentially trigger or exacerbate this rumination, thereby affecting sleep quality.

· Anxiety Disorder

Anxiety disorders can be positively predicted by IA, and they are linked to compromised sleep quality [25]. Anxiety can activate the HPA axis and the Corticotropin-Releasing Hormone (CRH), thereby affecting sleep [26,27]. When subjected to certain stimuli, the HPA axis is activated, affecting sleep. Additionally, anxiety can increase the secretion of CRH, and animal studies have confirmed that this can affect the balance of Rapid Eye Movement sleep and Slow-Wave Sleep, possibly leading to changes in sleep architecture. In conclusion, anxiety, through the activation of the HPA axis and CRH, could alter the quality and structure of sleep [28]. However, although anxiety disorders can be positively predicted by IA, more specific studies are needed to understand how anxiety interacts with IA to collectively affect an individual's sleep quality.

· ADHD

The primary symptoms of ADHD include inattention, hyperactivity, and impulsive behavior. These symptoms might be closely related to IA, as the amygdala, Insula, and the bilateral ventromedial prefrontal cortex, which govern emotional regulation, impulse restraint, and motivation, play a role in IA [22], closely related to the ability of an individual to focus, control impulsive behaviors, and deal with daily challenges - all of which are involved in criteria for diagnosing ADHD [22,29]. Concurrently, sleep issues are considered a primary characteristic of ADHD and might be related to the onset of ADHD symptoms as well as the exacerbation and co-occurrence of neurobehavioral deficits. Reports from parents and population-based research suggests that the occurrence rate of sleep issues in ADHD patients is significantly higher than in age-matched neurotypical individuals [30].

In summary, IA may adversely impact sleep by exposing users to a plethora of inconsistent information online, which might amplify the ruminative tendencies seen in depression or interact with the mechanisms associated with anxiety. Moreover, its close linkage with ADHD suggests a combined effect, further compromising sleep quality.

2.3 .The interaction and vicious circle between Internet addiction and sleep quality.

Although using weigh too much internet has been proved as a main factor of the lower sleep quality, and there exists loads of resources to justify this fact but the situation of whether people's own physical problem can affect the degree of internet use is still a hypothesis. Scientists have

made many experiences that illustrates there is a medium negative statistical correlation in the use of smart phone and sleep quality [20]. The participants are always college students and teenagers in these researches because the phenomenon appears the most in these two age groups. In one of the study shows that teenagers who spend huge amount of time on the internet tend to become lethargic in daytime due to the interruption of Circadian rhythm [31]. For example, adolescents, especially those who enjoy staying up late and playing games, this has often made them sleepy during the day at school and always sleepy in the morning. Thus, scientists firmly believe that there is a positive correlation between daytime sleepiness and internet addiction [31].It means internet addiction do lower the sleep quality as it make sleep duration irregular.

However, In a study of Chinese college students got this statement: There must exists at least one sleeping disorder can influenced internet using. For instance like insomnia, poor sleep quality, short sleep duration may all can lead to internet addiction. It creates a vicious cycle between internet using and sleep quality but there are only a few document that discussed the relationship between these two behaviors [32]. The limitation is significant either, since most of them used Cross-sectional study so the available measurement options are also limited to sample size and statistics approaches [32]. Furthermore, In a study on German adolescents illustrates that night itself is closely related to addictive behavior, and Adam concluded that the type of circadian rhythm at night is considered a risk factor. Prat and Adan believe that staying up late may be related to psychological distress, which may translate into drug addiction. Even though this is not the focus of our research, it can be concluded that night time personality itself may lead to addiction tendencies [33]. Similarly, Barnes and Meldrum pointed out that people who usually have a low sleep quality tend to have a poor self-control ability so this may also be a factor of becoming internet addicted [33]. Moreover there are some treatment can improve sleep quality through music especially for classical music, many nurse choose to use this way to treat insomnia symptoms in children [34], this means that internet addicts with sleep disorders may reduce internet addiction because of improved sleep quality [34].

3. Discussion

Internet addiction was significantly related to a wide range of health outcomes, especially in adolescents, such as impaired mental health, academic failure, and decreased work performance [35-38], and low sleep quality was one of the most significant effects among those. However, in the current treatment for Internet addiction, except

for the most commonly used motivational enhancement therapy and cognitive behavioral therapy (CBT), there is no golden standard for specific forms of psychological intervention for Internet addiction[39]. This review aimed to investigate the relationship between IA and poor sleep quality. The literature search shows that various studies explore the association between internet addiction and sleep quality from a neurological or psychological point of view.

In this review, first, in terms of mechanisms, the effects of melatonin, dopamine, and cortisol are more common than other neuromodulating factors in people with low sleep quality affected by Internet addiction [5] [6] [11] [12] [15] [16]. Hormone production due to internet addiction could, on the one hand, lead to poor sleep quality. On the other hand, hormone levels are likely to cause another comorbidity besides internet addiction. Further, previous studies have also found that depression, anxiety, and other negative emotions produced in stressful situations will negatively mediate sleep quality [40].

According to the above results, this review analyzed that in the case of sleep problems such as difficulty falling asleep or sleep restlessness in individuals with internet addiction caused by adverse physiological and psychological factors, low sleep quality would also enhance the severity of Internet addiction due to the reaction of physiological and intermediary factors. Therefore, a vicious circle of mutual influence exists between Internet addiction and sleep quality.

This review could have some implications for constructing a specific treatment for internet addiction to help individuals cope with adverse reactions in the context of various functional problems caused by addiction. For example, in general assumptions, researchers often assume that a decline in cognitive performance accompanies a decline in sleep quality. However, there is a considerable amount of evidence for no association between subjective sleep quality and the measured cognitive processes [41]. The reason why is among adults with normal behavioral abilities, the effect on sleep quality might not play a role when the impact of the negative symptom is not particularly profound [42].

As for people with decreased sleep quality caused by Internet addiction, we often cannot determine the order between the two. Then, the commonly used treatment is likely to have some obvious shortcomings. We can often use cognitive behavioral therapy or motivational enhancement therapy to address most individuals with sleep disorders. However, for individuals with poor sleep quality, which cannot be determined to be sleep disorders, treatments are rarely provided to these individuals with continuous support to help them improve. In other words,

there are currently no solutions to support individuals to prevent or reduce the deterioration of their symptoms in the stage where the decline in sleep quality caused by internet addiction is not profound. In addition, if the effect of the vicious circle is more serious than the interaction between Internet addiction and sleep quality, should we focus on interrupting the vicious circle in establishing future treatment methods rather than blocking Internet addiction or improving sleep quality? It might also be a topic that deserves a lot of attention.

4. Conclusion

In conclusion, there is a significant vicious circle in bi-directional connection between Internet addiction and sleep quality. However, more observational studies and cases are needed to find the order between the two and the severity of the effects and establish more effective and targeted therapies.

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