SYSŁO, Oliwia, JUNG, Maximilian, JUNG, Magdalena, JAWORSKI, Aleksander, SŁOWIŃSKA, Barbara, JASIŃSKI, Dawid, JUNG, Samuel, WOŹNIAK, Kinga, JĘDRAL, Krystian and CZYŻ, Sandra. How electronic devices affect the sleep of young people: summary of current knowledge. Journal of Education, Health and Sport. 2024;71:49444. eISSN 2391-8306.
https://dx.doi.org/10.12775/JEHS.2024.71.49444
https://apcz.umk.pl/JEHS/article/view/49444

The journal has had 40 points in Minister of Science and Higher Education of Poland parametric evaluation. Annex to the announcement of the Minister of Education and Science of 05.01.2024 No. 32318. Has a Journal's Unique Identifier: 201159. Scientific disciplines assigned: Physical culture sciences (Field of medical and health sciences); Health Sciences (Field of medical and health sciences).
Punkty Ministerialne 40 punktów. Załącznik do komunikatu Ministra Nauki i Szkolnictwa Wyższego z dnia 05.01.2024 Lp. 32318. Posiada Unikatowy Identyfikator Czasopisma: 201159. Przypisane dyscypliny naukowe: Nauki o kulturze fizycznej (Dziedzina nauk medycznych i nauk o zdrowiu); Nauki o zdrowiu (Dziedzina nauk medycznych i nauk o zdrowiu).© The Authors 2024;
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The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 16.03.2024. Revised: 10.05.2024. Accepted: 14.05.2024. Published: 20.05.2024.

How electronic devices affect the sleep of young people: summary of current knowledge

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ABSTRACT:

Introduction and purpose: The impact of electronic devices on our daily lives is becoming increasingly significant. The contemporary generation of young people is growing up in a world where smartphones, tablets, computers, and other electronic devices are widely available and utilized. Scientists are contemplating the challenges posed by excessive exploitation of electronics on the health of young individuals. The aim of the article is to present the harmful effects of using electronic devices before sleep in young people, considering medical aspects such as sleep disorders and their influence on overall psychophysical health.

Summary: Electronic devices negatively affect the sleep of young people by reducing sleep time and delaying the sleep onset phase. The main problem is the use of electronic devices without time limits. In the era of technology, it is significantly important to raise awareness among young people about the importance of sleep hygiene and how blue light emitted by electronic devices affects its quality.

Materials and Evidence: A literature review was conducted in the PubMed database using

Keywords: youth, sleep disorders, melatonin, electronic devices, blue light.

Introduction:

Sleep is one of the most crucial biological processes, essential for the functioning and maintenance of health in the body [1,2]. It helps us regenerate both physically and mentally, influencing physiological, psychological, and emotional processes [2]. Sleep problems are not only limited to older individuals; an increasing number of young people are beginning to struggle with this issue [14,15,17]. Factors such as stress, tension, unhealthy lifestyle, and primarily excessive exposure to blue light emitted by electronic devices can disrupt the ability to fall asleep and maintain healthy sleep [3,4]. Consequently, this may lead to long-term disturbances in both physical and mental health [32]. In this article, we will focus on

analyzing the fundamental neurobiological processes occurring in the body and sleep pathologies that may be associated with excessive use of electronic devices by young people. We will also examine the results of recent scientific research and practical clinical aspects aimed at increasing awareness of sleep hygiene among young individuals.

The role of the pineal gland and melatonin

The pineal gland, also known as the epiphysis, is a neuroendocrine gland about the size of a soybean seed, located in the posterior part of the brain's skull base. It is an organ of variable size, with an average mass of around 150mg in adult humans. Anatomically, the pineal gland is situated near the third ventricle of the brain and serves as a significant point of connection between the central nervous system and the hormonal system [5]. Its sympathetic innervation originates from the superior cervical ganglion, while parasympathetic innervation comes from the ciliary and pterygopalatine ganglia[6].

The main function of the pineal gland is synthesizing and secreting the hormone melatonin[5,6,7]. Melatonin, produced from the amino acid tryptophan, plays a significant role in regulating various physiological processes. Among the most important tasks of this hormone is the regulation of circadian rhythms, which involves synchronizing external factors such as changes in light and darkness with the body's internal biological rhythms[7,8,9,10,11].

The changing photoperiod, or the duration of light and darkness throughout the day, is a significant signal that responds to environmental changes. All photoperiodic organisms utilize the day-night cycle to regulate their seasonal physiology. As a result, melatonin secretion increases at night, while during the day, the level of this hormone decreases[7]. Recent studies have highlighted that melatonin also influences cell protection, neuroprotection, reproductive functions, body temperature, immunity, and the cardiovascular system[8].
Since the first isolation of melatonin from bovine pineal gland in 1958, its physiological functions have been continually rediscovered. Melatonin, also known as N-acetyl-5-methoxytryptamine, is an exceptionally conservative molecule, present not only in vertebrates but also in invertebrates, bacteria, plants, protists, and fungi [9].Melatonin is released in micromolar concentrations from extrapineal synthesis sites and has paracrine, autocrine, and antioxidant effects. Scientists are constantly discovering new functions of melatonin in the

body, noting that not only the pineal gland plays a crucial role in its production. Interestingly, it has been found that organs such as the intestine, retina, placenta, specific brain regions, and skin have the ability to produce melatonin, utilizing the same pathway as the pineal gland[10]. Additionally, melatonin has two types of G protein-coupled receptors, called MT1 and MT2, which are expressed in many different organs and tissues[8,11]. However, this topic goes beyond the scope of the discussion regarding the impact of electronic devices on the sleep of young people.

Significance of blue light in modulating human behavior and circadian rhythm

Sleep is crucial for our daily functioning and overall health and well-being. For young people, it is recommended to get 7 to 9 hours of sleep per day, which is important for maintaining optimal performance and health [12]. Over the last five decades, there has been a reduction in the average duration and quality of sleep, leading to detrimental effects on overall health [31]. A study conducted on approximately 3000 children aged from birth to 7 years old revealed that sleep problems are becoming increasingly common. According to this study, almost 60% of the children have atypical sleeping patterns: the majority of whom were initially short sleepers (45%), others were either persistent short sleepers (12%), or poor sleepers (3%). These findings suggest that sleep problems are common among young children, which may have significant implications for their health and development. It is worth examining the factors influencing sleep in young people[13].

Undoubtedly, the influence of social media on the social lives of young people is increasingly prevalent. These tools have become an integral part of daily life, including interpersonal communication through online platforms. On average, young people spend 2 hours a day on various social media apps, and this trend continues to rise[14]. Unlike sports activities or school-related tasks, using social media does not have a defined start and end point[15]. Additionally, the Covid-19 pandemic significantly affected changes in the habits of young individuals, which contributed to alterations in social interactions and greatly impacted sleep quality. Researchers have begun studying the impact of social media on changes in the psychological behavior of young individuals. It has been proven that social media platforms can significantly influence the mental health of young people by affecting mood changes. Individuals who passively use these platforms, without a specific goal, may experience mood fluctuations depending on the nature of the content they browse. This, in turn, can lead to the

transfer of both positive and negative moods among the population through social networks. There is a high risk that young individuals may be exposed to comparing themselves to others and developing unrealistic expectations of themselves or others, which can lead to various affective consequences such as decreased self-worth, increased feelings of loneliness, or exacerbation of symptoms of depression and anxiety[14]. According to existing research, frequent use of social media platforms has shown the greatest impact on reducing sleep time and feelings of anxiety caused by media content related to violence or sexuality[15].

However, not only content related to electronic devices has a significant impact on our health and well-being, but also the blue light emitted by these devices. Sources emitting blue light, such as computer screens, televisions, smartphones, and tablets, can disrupt our sleep patterns and affect its quality[14,15,17].

Light is composed of various wavelengths, which include the colors red, orange, yellow, green, blue, indigo, and violet[16]. Electronic devices such as smartphones, tablets, and computers emit light with a high content of blue spectrum, where the wavelength ranges between 400-490 nm[17]. Our exposure to light, especially to short-wavelength and high-energy waves, is associated with the perception of the color blue, which exhibits a significant sensitivity to our circadian rhythm[16]. Our biological clock, located in the suprachiasmatic nuclei of the hypothalamus, is primarily synchronized by the solar cycle[17].

For young people, an excess of blue light can be particularly harmful because exposure to it before sleep can disrupt the production of melatonin - the hormone regulating the circadian rhythm and sleep. Prolonged use of devices emitting blue light before sleep can trick the brain into thinking it is still daytime, delaying the secretion of melatonin and making it difficult to fall asleep. The effects of this can be particularly severe in older age, where there is a greater risk of sleep and circadian rhythm disorders[15,17,31].

Studies suggest that exposure to blue light can lead to changes in the structure of the eye, such as pupil size reduction and changes in lens density, as well as retinal damage. The most common type is retinal damage through photochemical action, which occurs due to exposure of the eyes to high-intensity light in the visible spectrum (390–600 nm). These changes may contribute to further sleep rhythm disturbances later in life [17].

Effects of Late-Night Electronic Device Usage on Academic Achievement, Cognitive Functioning and Sleep Quality

According to research, three-quarters of American children and teenagers report having at least one multimedia device in their bedroom, and approximately 60% declare regular use of these devices an hour before bedtime[18]. Continuous exposure to devices emitting blue light at night can have a negative impact on attention and verbal memory. A significant issue is keeping electronic devices next to the bed or under the pillow while sleeping, which in turn shapes poor habits caused by difficulties falling asleep. Notifications and sounds coming from an unturned-off phone lead to constant awakenings, thus deteriorating sleep quality. Consequently, this manifests in worsened academic performance due to the loss of mental focus and decline in cognitive functions, such as memory, as well as constant feelings of fatigue and exhaustion[19]. Additionally, there is a growing concern that technology addiction can reach an uncontrollable and excessive level, leading to disruption of normal daily functioning. There is a tendency to observe noticeable psychosocial dysfunctions in individuals who cannot limit excessive use of social media[18].

Lack of sleep in children and adolescents has wide-ranging consequences associated with an increased risk of obesity, disruption of mental health, and impairment of cognitive function[19,20]. Sleep affects two main effector systems, the hypothalamic-pituitary-adrenal axis and the sympathetic nervous system, which in turn regulate acquired and innate immune responses. Lack of sleep and its disturbances impair acquired immunity. This impairment manifests as a reduced response to vaccines and increased susceptibility to infectious diseases. Two mechanisms influence the decreased immune response: a decrease in growth hormone levels during slow-wave sleep and an increase in sympathetic nervous system activation[20]. Additionally, sleep-related disorders are associated with increased inflammation, characterized by high levels of growth hormone and prolactin and low levels of cortisol and catecholamines, negatively affecting adrenergic signaling and controlling the expression of inflammatory genes[20,21].

An interesting fact is the close relationship between inflammation and depression. There is evidence that inflammatory states may contribute to the development of depression. Interestingly, partial induction of these inflammatory states may be related to sleep

disturbances[20]. Researchers have shown that sleep disorders, such as insomnia, difficulty initiating or maintaining sleep, and depression are closely linked and bidirectional in nature. These mutual associations may inform the pathophysiology underlying each condition. However, insomnia is not the only symptom of depression; it may play a role in predicting the risk of depression. Even in individuals without a history of depression, persistent insomnia may predict the risk of depressive symptoms over six years[22]. This is noteworthy as unipolar depressive disorder is a common mental health issue among teenagers worldwide, with an estimated prevalence rate of 4–5% in the middle and late adolescence[24]. Sleep disturbances such as short and long sleep, symptoms of insomnia, and depression are risk factors for worsening health in later life, including increased risk of cognitive decline, falls, and consequently, poorer quality of life[23]. The relationship between insomnia and depression may be crucial in the approach to treating both conditions. Adding cognitive-behavioral therapy for insomnia to standard antidepressant treatment may provide faster and more enduring remission of depression than standard treatment alone[22,23].

Insomnia and obesity

Laboratory studies on healthy individuals have shown that recurrent partial sleep restriction leads to decreased glucose tolerance and insulin sensitivity[25,26]. Sleep restriction is associated with changes in energy homeostasis, insulin resistance, and the functioning of pancreatic beta cells responsible for insulin production[27]. These alterations in glucose metabolism may contribute to the development of diabetes and obesity. These findings are medically significant as they suggest that sleep deprivation may be a risk factor for metabolic disorders and related diseases[25,26,27]. Additionally, shortened sleep duration can lead to excessive calorie intake due to increased hunger and reduced appetite control, which also translates into abnormal glucose processing and disturbances in circadian rhythm[3,26]. Encouraging good sleep habits and raising awareness about the effects of sleep on metabolism can be vital approaches in preventing these conditions[3,25,26,27].

Sleep measurement

Sleep can be objectively assessed using polysomnography, a method that involves continuous recording of physiological parameters throughout the night. This provides information about neurophysiological and cardiorespiratory changes in various systems and allows for the qualitative and quantitative assessment of sleep disturbances between wakefulness and sleep[28].

Another method used to assess sleep is actigraphy, which involves monitoring movement using small electrical devices worn on the body. Actigraphy is extremely useful for evaluating sleep quality, allowing for more accurate adjustment of therapy to meet the patient's needs[29]. Additionally, sleep diaries and self-report questionnaires allow patients to monitor the number of awakenings during the night and the duration of sleep. This information is highly relevant in the diagnosis of insomnia disorders by the physician[20].

Sleep health promotion

Mainly, the Internet serves as the primary source of extracurricular knowledge acquisition for young people. To keep up with the development of technology and the dynamics of social media, it is crucial to examine the issue from the perspective of content assimilation by young individuals. The main advantage of the Internet is its easy accessibility for most people, especially in developed countries, where it is difficult to find someone nowadays who does not use electronic devices such as tablets, phones, or TVs. The COVID-19 pandemic has led young people to increasingly resort to electronic devices, thereby modifying their sleep-related habits. To better understand this issue, researchers conducted a survey involving 300 Brazilian students. Among the respondents, approximately three-quarters reported daytime sleepiness, anxiety, poorer sleep associated with stress, or anxiety. Furthermore, 53.2% of the participants did not try to avoid screens before bedtime, and around 79.3% spent time in bed after work or watching TV. In order to reduce harmful pre-sleep behaviors among young people, scientists created profiles on social media platforms such as Facebook and Instagram, thereby promoting healthy sleep hygiene tips. The published content mainly focused on regular sleep schedules, avoiding electronic devices, and relaxation before bedtime. The results of the study suggest that thanks to the published content and easy access to information, the quality of sleep among young people has improved. Therefore, utilizing social media for

health promotion can be an effective strategy in educating students about sleep hygiene. Undoubtedly, further research is necessary to better understand the impact of social media on the assimilation of health-related content by young people[30]. Meanwhile, it is worthwhile to undertake preventive actions focusing on behavioral therapy among both adolescents and parents to increase awareness about sleep disorders and their impact on the development of deficit-related diseases[20,30].

Sleep hygiene

Maintaining healthy sleep habits is crucial for overall health, especially among students, where a decrease in average sleep hours has been observed, correlating with various issues such as attention deficit, poorer academic performance, difficulties in social relationships, and overall deteriorated health[17]. Given society's habits of using electronic devices before bedtime, an important aspect to raise awareness among young people is understanding the biological clock and its positive effects on functioning[14,15,20]. The biological clock, also known as the circadian rhythm, is an endogenous regulatory mechanism that has evolved in organisms to adapt behavior and physiology to the cyclical changes in the environment, mainly light and darkness. This internal clock has been developed by invertebrate and vertebrate species to synchronize with the 24-hour cycle on Earth. At the molecular level, the biological clocks involve a set of clock genes organized in a system of interconnected transcriptional-translational feedback loops. The ubiquitous network of cellular, central, and peripheral tissue genes coordinates physiological functions throughout the day by activating tissue-specific transcriptional programs[1]. The circadian rhythm is physiologically important as it regulates our lives, including the cardiovascular system, energy metabolism, immunity, hormone secretion, reproduction, and regeneration[32].

To better care for our biological clock, attention should also be paid to stimuli that can prolong our time to fall asleep. Stress and exposure to factors such as electronic devices can lead to difficulty falling asleep. The use of relaxation techniques, as well as disconnecting from stimuli before bedtime, can help reduce tension and facilitate falling asleep. In this case, it is worth getting rid of all electronic devices from the room that emit blue light, which disrupts melatonin production. Additionally, ensuring a quiet and cool room can facilitate

falling asleep. Favorable sleeping conditions improve sleep quality. The ambient temperature plays a significant role. Slightly cool environments promote deeper sleep, while hot environments can lead to more frequent awakenings. The optimal temperature in the bedroom should be between 16 and 18°C[2].

Moreover, popular among students, alcohol and caffeine can significantly affect sleep by prolonging the time to fall asleep. Although alcohol may initially seem relaxing, it is quite the opposite. Consuming alcohol before bedtime disrupts the REM (rapid eye movement) sleep phase, affecting its quality, which in turn leads to disruptions in the body's regeneration[2]. It is also advisable to avoid consuming high-fat foods just before bedtime, as they not only negatively affect sleep but also increase the risk of obesity and metabolic disorders such as dysbiosis, lipid accumulation in the liver, and systemic inflammation[3].Undoubtedly, regular physical activity has a positive impact on both the physical and mental aspects of our bodies. However, it is advisable to avoid intense exercise just before bedtime, as it can increase psychomotor arousal and make it difficult to fall asleep[2].

Disclosure:

The authors declare that they have no financial or non-financial conflicts of interest that could be perceived as influencing the interpretation of the research findings or the content of this manuscript. This work was conducted independently without any external funding or support.

Author’s contribution:

Conceptualization: Oliwia Sysło,Maximilian Jung; methodology: Oliwia Sysło, Sandra Czyż; software:Krystian Jędral; check: Samuel Jung; formal analysis:Kinga Woźniak, Dawid Jasiński; investigation: Maximilian Jung, Aleksander Jaworski; resources: Samuel Jung; data curation: Barbara Sławińska; writing – rough preparation:Oliwia Sysło, Maximilian Jung; writing – review and editing: Maximilian Jung, Sandra Czyż, Aleksander Jaworski; visualization: Krystian Jędral; supervision: Kinga Woźniak; project administration: Samuel Jung; receiving funding: Not applicable All authors have read and agreed with the published version of the manuscript.

Statement regarding funding:

The authors declare that there are no conflicts of interest or financial disclosures associated with this scientific work.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Our work did not involve direct human subject research or obtaining their consent for participation in the study.

Data Availability Statement:

Since this is a review paper, our work does not contain new data or analyses. Consequently, there are no particular databases or data accessibility to outline. The details and conclusions presented in this review are derived from previously published studies, which can be accessed through their respective sources as mentioned in the reference section

Conflicts of Interest Statement:

The authors assert that there are no notable conflicts of interest linked to this research endeavor.

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