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Review Article

The Impact of Overexposure to Digital Screens in the Neurodevelopment of Children and Adolescents: A Literature Review

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Abstract

The use of technology has increased significantly worldwide since it plays an important role not only as a means of communication, but also as a source of information and entertainment. Due to its constant use, certain disorders associated to digital screen exposure have been studied. However, the global virtualization of education in the last two years associated with the SARS-CoV-2 pandemic has created a significant increase in digital screen exposure, meaning recommendations regarding safe exposure provided by the World Health Organization (WHO) have continuously been ignored. Given this situation, concerns have risen regarding the impact of overexposure to digital screens on the neurodevelopment of children and adolescents; thus, a review of various databases was carried out where literature from 2013 onwards was selected and studied. This review describes the negative impact of digital overexposure on the pediatric population, such as failures in cognitive development due to modifications in the brain's configuration. We should be made aware of these effects in order to prevent them through good habits related to the use of digital screens.

Keywords: Neurodevelopment; Addiction; Brain; Children; Internet; Digital screens

Introduction

Exposure to digital screens over an interval of time is known as screen time [1]. The World Health Organization (WHO) recommends limiting screen exposure to one hour per day for children under five years of age; however, many parents or guardians are unaware of this pattern and expose minors to digital screens without any regulation [2,3]. It has been described that, with advancing age, there is also an increase in the hours of use [4]; nevertheless, in the last decade, this phenomenon has reached younger populations [5]. A study carried out in 2018 reported that 98% of American children under the age of eight live in a home where there is at least one device with Internet connection, which is used for an average of two hours and nine-teen minutes a day [6]. In addition, due to the SARS-CoV-2 pandemic, there has been an exponential increase to digital screens as a means of work, entertainment, and education [7,8]. Childhood corresponds to a period of high vulnerability in human development in which the stimuli they receive are essential for the formation to become healthy adults [9,10]. Therefore, overexposure to digital screens has shown to affect various functions in the neurodevelopment of the pediatric patients such as vision (myopia and blindness at an early age), the circadian cycle (problems falling asleep), and mental health concerns. An increase in sedentarism, consequential of the excessive use of digital screens, might also result in overweight or obesity since physical activity is replaced by video games. Psychiatric disorders such as depression and digital addiction might also appear due to the problematic use of social networks [11]. The objective of this literature review is to evaluate the association between the excessive use of digital screens and the effect on neurocognitive development in the child and adolescent population.

Methodology

The literature search was conducted on the following databases: National Center for Biotechnology Information, Google Scholar and EBSCO host, with keywords "brain", "digital screen", "neural development" and "children". The search was then narrowed down by using the Boolean operator "brain AND digital screens", in which 4,472 articles were found. The range of years that was considered when selecting the articles was between 2013-2021. Additionally, studies that did not have a clear methodology, and those with data on populations older than 18 years, were excluded; ergo, a total of 25 articles will be discussed in this review.

Child Neurodevelopment

Child neurodevelopment is a process of the Central Nervous System (CNS) whose objective is the adaptation of the infant to its environment through behavioral models that involve the dynamic interaction between them [12]. This process is related to the integration of information in which both external and internal contexts are involved. The external environment is made up of stimuli from society, culture, and physical surroundings; on the other hand, the internal environment includes processes at the CNS level, such as cognitive development [5]. The first stage of cognitive development comprises the first three years of life where the brain gyri and sulci develop due to its neuroplasticity [10]. This developmental process encompasses the ability of the nervous system to modify itself to form nerve connections in response to new information, such as structural or functional changes in the neuron, allowing the nervous tissue to develop adaptive or reorganizational changes in a physiological state with or without alteration [13]. During this stage the cognitive capacities, that in the future will form the executive functions, are established. These functions are considered as a set of cognitive, affective, and motivational processes that allow self-regulation of both mental and behavioral operations for the effective resolution of a problem [14]. The development of cognitive functions occurs gradually and slowly; hence, the first years of life has a wide spectrum of vulnerability to external risk factors [10]. This stage is also considered a critical and sensitive period since it is a window of time that allows the development of a certain skill. A positive interaction with the environment is necessary as a means of stimulation for the development and strengthening of various brain skills [12]. The brain's "reward system" oversees the sensation of pleasure in the body [15]. This system is activated by different behaviors such as eating or reproducing, which cause pleasure and are susceptible to developing an addiction. The reward pathway is not located in a single area of the brain but is distributed in various regions such as the ventral tegmental area (VTA), the nucleus Accumbens (NAc) and other specific areas of the limbic system [16]. This system includes several neural pathways which, through the neurotransmitter dopamine, allow the flow of information between the involved structures. Dopamine is responsible for regulating the body's motor activity and it is secreted with the arrival of a pleasant stimulus [11]. Dopaminergic neurons have three patterns of activity: the inactive state, the tonic state, and the phasic state. The phasic activity is the most important in this process since it generates the release of dopamine, which allows the opening of the permissive afferent "gate" and gives access to the dopaminergic neurons to respond to glutamate and initiate burst firing (phasic activity) which indicate reward and modulate goal-directed behavior [15].

Effects of Digital Screens on Neurocognitive Development

Various articles guarantee that there is a direct relationship between the prolonged use of digital devices and a decrease in school performance due to problems in cognitive and language development [4]. According to a study carried out by researchers from Ecuador in infants between one and two years of age, it was shown that screen time affects the development of the Intellectual Coefficient (IQ), showing a deficiency in the development of the IQ of 42% when starting exposure to digital screens between six months and two years of age [17]. Exposure to technology from an early age tends to have a negative impact on brain neuroplasticity, which is reflected as low cognitive level and behavioral problems such as: low self-esteem, aggressive behavior due to violent video games, and socializing problems due to difficulties in language development [10]. In Peru, a study analyzed the different learning disorders and their relationship with the use of new technologies. Some of the cognitive disorders that were observed were dyslexia, dyscalculia, dysgraphia, dysorthography and dysphemia; all these have a neurological component, which indicates that they are innate problems. However, due to the increase of technological exposure in daily life, certain characteristics of these disorders have been observed in new generations even without presenting deficits at birth. According to this study, the learning areas most affected by the problematic use of digital devices are language and attention, indicating a detrimental relationship between the indiscriminate use of these devices and the presentation of long-term learning problems [3]. The use of technologies, apart from hampering cognition development, is also associated with the appearance of attention disorders whose etiology is still uncertain. One of the hypotheses states the cause could be associated with the performance of concomitant tasks, which reduce the opportunity to interact outside of virtuality and decrease time for the nervous system to "rest"; in this way, executive functioning is impaired [18]. By exceeding the threshold of two hours a day for exposure to screens, the risk of developing attention deficit hyperactivity disorder (ADHD) also increases [10]. In the United States, a case-control study was conducted with three-year-olds predisposed to ADHD and non-prone children. The study showed that those who belonged to the risk group had a greater screen time than the comparison group. Thus, it was proven that this association existed before the development of ADHD symptoms [19]. On the other hand, in a study carried out on 47 preschool children, it was shown that overexposure to screens was associated with a lower integrity in the microstructure of the cerebral white matter tracts responsible for executive and language functions, reflecting poor phonological processing, poor vocabulary, and emotional processing disabilities [20]. Another cohort study, which compared the microstructure of white matter with physical activity and screen time, found that the use of digital screens is not directly associated with the development of the white microstructure but rather it replaces the time of physical activity, which in turn alters white matter development. [21]. It was concluded that overuse of digital screens does not provide benefits for its development, but it does take time away from activities that would have a positive impact on this area [18,21].

Digital Screen Exposure and Behavioural Addiction

Exposure to digital screens greater than 25-30 hours per week is defined as behavioral addiction, involving a gradual change of the reward system where the individual pathologically tries to obtain a pleasant sensation [2,15]; additionally, the concept of Internet addiction is known as Internet Addiction Disorder (IAD) [11]. These disorders are associated with clinically significant functional impairment in measures of self-control, interpersonal relationships, behavioral disorders, and emotional stability [22]. Despite the brain alterations that IAD produces, this disorder is not classified in the mental disorders of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) [11]. Regardless, IAD can be identified as an impulse control disorder characterized by uncontrolled use of the Internet. Within the DSM-V criteria, it can be categorized as "Other specified destructive, impulse control and behavior disorder" [22]. The literature related to IAD has focused mainly on the use of the Internet for video games; however, the increasing digitization in all aspects of life involves the prolonged use of school applications and social networks which could also contribute to addiction [23]. Recently, brain imaging studies have been conducted to determine the different neural mechanisms involved in IAD. The neuroimaging findings conclude that ADI shares similarity with the addictive behavior that occurs in substance dependence, both emotionally and behaviorally. Overuse of the Internet has shown to be related to abnormal neurobiological mechanisms in the frontal lobe, striatum, and somatosensory regions [24]. These mechanisms can lead to a decrease in the thickness of the frontal cortex and a reduction in the volume of the gray matter respectively [25]. The affected brain regions are primarily involved in impulse control, the reward processing system, and the somatization of previous experiences [26]. The frontal lobe is related to cognitive functions, empathy, and adaptation to environmental changes, which lead to alterations in lifestyle and behavioral disorders in children and adolescents. Consequently, errors develop in the ability to discriminate information and adapt to complicated tasks, as well as impairments in the ability to manage time, energy, and attention [24].

Conclusion

Overexposure to digital screens in children and adolescents influences neurodevelopment in areas such as learning, IQ and behavior. Different studies have shown that there is a direct involvement with respect to the formation and stimulation of different anatomical structures related to neurodevelopment, such as the brain white matter, the frontal and prefrontal cortex. In this way, a decrease in school performance, difficulty in language development, an increase in predisposition to ADHD and the development of ADI are all observed in the studied populations. To prevent such effects, it is encouraged to practice the recommendations provided by the WHO on exposure to digital screens in the child and adolescent population, such as not allowing digital screen exposure in children under 24 months of age. This is a critical period to achieve optimal brain development and recommendation follow as such: limit the screening time to 30 minutes a day for in children 2-5 years of age, lower screen brightness and avoid use in dark environments. It is also suggested to avoid the use of digital screens as a reward strategy, a distraction or as an incentive to complete different basic activities, such as a method to help feed children that refuse to eat. Finally, if it is decided to implement technological devices as a teaching method, it is recommended to have a companion with whom the infant can have a joint interaction [6].

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