

DIGITAL SCREEN DEVICE AND INTERNET USE AND SLEEP DISTURBANCES: A SYSTEMATIC REVIEW OF THE EVIDENCE (2014–2020)

DISPOSITIVOS COM ECRÃ DIGITAL E UTILIZAÇÃO DA INTERNET E DISTÚRBIOS DO SONO: UMA REVISÃO SISTEMÁTICA DA EVIDÊNCIA (2014–2020)

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ABSTRACT

This systematic review examines the relationship between new technologies and sleep disorders and the influence of these technologies on sleep quality. To this end, articles published between 2014 and 2021 were selected, which were open access, complete, published in scientific journals and peer-reviewed, and addressed the relationship between new technologies and sleep disturbances and/or quality problems and the amount of sleep. After reading and analyzing the subsections of the results for the selected articles, discussions on the relationship between new technologies and sleep quality/disturbances were constructed. The analyzed authors point out that new technologies have a negative impact on sleep quality, leading to daytime sleepiness and difficulty falling asleep, especially when used at night. Studies on this topic remain scarce, underscoring the need for further research better to understand the effects of new technologies on sleep.

Keywords: new technologies, sleep disorders, effects of the use of new technologies on sleep quality, abuse of new technologies

RESUMO

A presente revisão sistemática objetiva compreender a relação entre as novas tecnologias e as perturbações do sono, bem como sua influência na qualidade do sono. Para tal, foram selecionados artigos publicados entre 2014 e 2020, em open access, completos, publicados em revistas científicas e revistos pelos pares, que abordassem a relação entre novas tecnologias e perturbações do sono e/ou problemas na qualidade e na quantidade do sono. Após a leitura e análise, foram construídas as subseções de resultados referentes aos artigos selecionados e as discussões sobre a relação entre novas tecnologias e a qualidade do sono/perturbações do sono. Os autores analisados apontam que as novas tecnologias influenciam negativamente a qualidade do sono, gerando sonolência diurna e dificuldade para adormecer, sobretudo quando utilizadas à noite, nos momentos imediatos antes de adormecer. Os estudos sobre essa temática ainda são escassos, o que reforça a necessidade de compreender melhor os efeitos das novas tecnologias no sono, com mais pesquisas e estudos nessa área de investigação.

Palavras-chave: novas tecnologias, perturbações de sono, efeitos do uso de novas tecnologias na qualidade de sono, abuso das novas tecnologias

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Mobile devices are among the most useful technologies in contemporary life, not only for their communication capabilities but also for the many applications they enable, including internet browsing, instant messaging, social media, music playback, email sending, and entertainment through games. The technological advances and possibilities integrated into these devices far transcend their initial proposal to facilitate communication. Currently, they are true portable computers that are increasingly becoming indispensable in citizens' daily lives (Tymofiyeva et al., 2020). Among other benefits, they facilitate social interaction and multitasking. However, they can impair young people's learning, as their excessive use can bring other less positive consequences, such as sleep deprivation, stress, and depressive symptoms, as well as decreased melatonin production, increased cognitive and emotional excitability at bedtime, and therefore prolonged sleep latency (Ferrari Junior et al., 2024; Richardson et al., 2021).

The rapid increase in the use of these electronic social communication means in recent years raises concerns that they may be adversely affecting the quality and total quantity of sleep (Brautsch et al., 2022). The indiscriminate use of devices such as computers, tablets, smartphones, video games, and televisions directly affects an individual's quality of life (Ferrari Junior et al., 2024). According to the World Health Organization (WHO), quality of life is defined as the perception that an individual has about their position in life, in the context of the cultural and value systems in which they are inserted and in relation to their objectives, expectations, standards, and concerns (World Health Organization, 2022).

Internet access is an integral part of the capabilities of smartphones, having become popular today and a part of the daily lives of countless people around the world as a means of information, socialization, and entertainment (Kokka et al., 2021). Internet use has

been frequently debated, raising the central question of the need to define healthy limits for its use and the consequences of excessive use for the health and development of young people (Tereshchenko et al., 2021).

Many adolescents, however, take these devices to bed, use them in the hour before sleep, and wake up during the night to check for messages, a practice that can result in poor sleep quality and insufficient sleep, consequently with subsequent harmful effects on health and well-being (Hutsteiner et al., 2024). Recent studies demonstrate that on days with greater nighttime screen time and more smartphone unlocks, adolescents present later sleep onset and worse sleep quality, both self-reported and objectively measured by monitoring devices (Burnell et al., 2024).

Sleep is essential for human health and development. Some studies have demonstrated the existence of physical, psychological, and behavioral problems associated with deficient sleep or its absence, and despite its importance, it is quite common for children and adolescents to present sleep-related problems, especially due to the use of devices that provide continuous stimulation at any time and place (Silva et al., 2022; Windiani et al., 2021).

According to the National Sleep Foundation, good sleep quality is defined by: the person being able to sleep 85% of the time they spend in bed for sleep, with sleep onset not exceeding 30 minutes, having a maximum of one awakening during the night, and not having difficulty falling back asleep within 15 minutes immediately after that awakening. Although the number of hours of sleep during the night is a fundamental determinant in characterizing a "good sleep," sleep quality is the most important factor, as the quantity of hours slept varies greatly from one individual to another (Parlak et al., 2023).

Sleep-related problems among young adults and adolescents have been frequently associated with internet use (Kokka et al., 2021;

Tereshchenko et al., 2021) and with devices that combine multiple technologies (Richardson et al., 2021). A recent systematic review confirmed that all included studies reported negative correlations between problematic internet use and adolescent sleep, affecting both the quality and quantity of sleep and increasing insomnia symptoms (Kokka et al., 2021). Although there are several benefits to modern technology, its use can promote and exacerbate sleep deprivation in adolescents. Adolescents need 8 to 10 hours of sleep per night, which is more than the amount required for adults, as sleep requirements decrease throughout life. Since development and biological and psychosocial changes occur during sleep, this is crucial for maintaining adolescent homeostasis (Ferrari Junior et al., 2024).

Adolescence is associated with circadian phase shifts that conflict with social changes; thus, this important developmental period is often characterized by sleep deprivation. Sleep problems are also regularly reported in adolescence and can be categorized as insomnia (difficulties initiating and maintaining sleep) or other disorders such as daytime somnolence and parasomnias (night terrors, sleepwalking, and nightmares) (Brautsch et al., 2022; Silva et al., 2022).

Recent studies have documented an association between the use of electronic media and poor sleep quality and insufficient sleep quantity in school-age children (Windiani et al., 2021). However, the use of electronic media is becoming increasingly common in preschool-age children, beginning before age three. The recent emergence of electronic and tablet-based children's toys offers new learning opportunities but may also have unintended consequences on motor development, physical activity, attention, and sleep.

Excessive use of technology, especially among young people, has been associated with a series of health problems, including sleep disturbances. International studies revealed

high prevalences of smartphone dependence and sleep problems: in Turkey, 41% of adolescents presented smartphone dependence and 61% poor sleep quality (Parlak et al., 2023); in Indonesia, 58.24% of university students presented high smartphone dependence with significant insomnia symptoms during the pandemic (Indrakusuma et al., 2021); and in Turkish samples during COVID-19, 85.2% reported poor sleep quality, correlated with internet dependence measures (Tural-Büyük et al., 2022). A representative population study in Austrian schools demonstrated that the use of digital devices after midnight explained approximately 18% of the association between addictive behaviors related to the internet and insomnia symptoms (Lederer-Hutsteiner et al., 2024). These studies highlight the importance of balanced technology use to ensure healthy sleep.

Sleep is fundamental for daily functioning, so its restriction can lead to various negative consequences. Since lack of sleep is harmful to healthy functioning, it is essential to identify the factors affecting sleep so that we can minimize the negative consequences that may result (Ferrari Junior et al., 2024; Tereshchenko et al., 2021).

Sleep disturbances and insufficient sleep duration are associated with daytime somnolence and a wide range of health problems. For example, insufficient sleep negatively affects cognitive performance, mood, immune function, cardiovascular risk, weight, and metabolism (Brautsch et al., 2022). Recent studies have demonstrated that smartphone dependence is associated with alterations in neural networks, including changes in amygdala centrality, which correlate with a higher incidence of sleep problems and depressive symptoms in adolescents (Tymofiyeva et al., 2020). Additionally, internet dependence was positively associated with daytime somnolence and negatively with perceived quality of life in representative samples of adolescents (Ferrari

Junior et al., 2024). Various biological, psychosocial, and environmental factors contribute to insufficient sleep and sleep disturbances among adolescents and young adults, including biological changes in the accumulation of homeostatic sleep pressure (the probability of falling asleep), increased academic and professional demands, and the use of substances such as alcohol and caffeine.

The recognition of the importance of sleep quality for healthy development led to increased concerns about technology and its potential to disrupt bedtime behavior (Brautsch et al., 2022; Silva et al., 2022). During the nighttime period, adolescents' use of electronic media can affect the duration and quality of sleep, which can lead to problematic daytime functioning (Richardson et al., 2021). Recent longitudinal studies, using objective measurements through wearable devices (Fitbit) and smartphone screen captures, confirmed that daily variations in nighttime smartphone use predict, on the same night, later sleep onset and worse sleep quality, emphasizing the importance of timing of use (nighttime versus daytime) (Burnell et al., 2024).

Most external factors can be modified through changes in people's behavior. Understanding the relationships among these variables will help define activities to improve sleep. Longitudinal studies demonstrated that parental control over technology use can protect adolescent sleep, with time spent with technology mediating the relationships between parental controls and sleep outcomes in early adolescence (Richardson et al., 2021).

On the other hand, circadian types are intrinsic and heritable characteristics of the individual, associated with differences in habits, performance rhythms, and physiological and behavioral variables. Furthermore, circadian preference changes from pre-adolescence to adolescence, leading to adolescent sleep characterized by late bedtimes and later wake times (Brautsch et al., 2022).

Reading a book, listening to music, watching television, and using the Internet are common ways to help you fall asleep. People with sleep disturbances tend to spend more time on social media and watching television (Pirdehghan et al., 2021). Recent studies on social media use demonstrated that measures of nomophobia (fear of being without one's mobile phone) and addictive social media use predict longitudinal increases in insomnia symptoms over time in adolescent cohorts (Lin et al., 2021).

The period between 2014 and 2020 represents a fundamental milestone for research on the relationship between the use of new technologies and sleep disturbances, as it coincides with the global mass dissemination of screen-based portable devices, particularly smartphones and tablets, and with the methodological maturation of research in this area. During these years, there was a significant transition in how populations, especially young people and young adults, interact with digital technologies, with studies demonstrating that the median screen time reached 38.4 hours per 30 days in objective measurements, and that 85.5% of the population in representative samples already used mobile phones daily, with an average of 2.85 hours of use (Foerster et al., 2019). This period enabled the accumulation of robust evidence through meta-analyses, prospective cohort studies, and controlled laboratory investigations, which established consistent associations between nighttime use of electronic devices and multiple compromised sleep parameters, including inadequate sleep quantity (OR = 2.17), poor sleep quality (OR = 1.46), and excessive daytime somnolence (OR = 2.72) in children and adolescents (Foerster et al., 2019).

The relevance of this time interval is further reinforced by the convergence of epidemiological and experimental data that elucidated the biological mechanisms underlying the relationship between technology and sleep. Laboratory studies conducted during this period

demonstrated that exposure to short-wave light emitted by tablets and smartphones before sleep suppresses melatonin secretion, delays the circadian phase, increases sleep latency, and reduces REM sleep, providing a plausible physiological basis for the associations observed in population studies (Leger et al., 2020). Simultaneously, prospective investigations, such as the HERMES study, documented that adolescents with at least one nighttime awakening caused by mobile phone per month presented a significantly elevated risk of developing restless sleep (OR = 5.66) and difficulty falling asleep (OR = 3.51) over a one-year follow-up period (Foerster et al., 2019). The diversification of digital activities, including streaming, binge-watching, social media, and online gaming, intensified nighttime screen exposure and the risk of delaying sleep, creating new behavioral patterns with direct impact on sleep hygiene (Jindal, 2020).

The year 2020 marks a crucial turning point in this trajectory, with the COVID-19 pandemic and consequent lockdowns causing abrupt changes to daily routines and a substantial increase in time spent at home and in front of screens. Longitudinal studies conducted during lockdown, such as the Italian investigation with 2,123 participants, documented that individuals who increased device use in the two hours before sleep presented worse sleep quality, worsening of insomnia symptoms, reduced sleep duration, greater sleep latency, and postponement of bedtimes and wake times, with increased prevalence of “poor sleepers” and clinical insomnia throughout follow-up (Leger et al., 2020). Thus, the 2014-2020 period not only captures the natural evolution of the technological phenomenon and its impact on sleep but also encompasses an unprecedented disruptive event that exponentially amplified exposure to digital technologies, making this time interval essential for understanding both long-term trends and the acute effects of pandemic-induced behavioral

changes on population sleep patterns.

In this way, the research question that emerges from the clear and specific formulation is: Is there a relationship between new technologies and sleep disturbances?

Specific objectives were established to facilitate this systematic review, such as understanding the relationship between the use of electronic devices and the emergence of sleep disturbances; determining whether negative effects caused by new technologies on sleep quality are found; and understanding how excessive internet use can affect the development of a sleep pattern considered normal and of good quality.

METHODS

Based on a review of the literature published between 2014 and 2020. The present study aims to verify the effects of new technologies, such as mobile phones, television, games, and tablets, as well as the continued use of the Internet, on the emergence of sleep disturbances. To this end, a search was conducted across several databases, namely B-on, SciELO, PubMed, ScienceDirect, and Google Scholar.

As inclusion criteria, we selected articles published between 2014 and 2020 that were open access, complete, peer-reviewed, and addressed the connection between new technologies and sleep disturbances and/or sleep quality and quantity.

As exclusion criteria, we decided to eliminate articles that were not quantitative in nature, did not establish a relationship between the variables defined above, or were deemed irrelevant to the analysis in question. After several attempts using keywords such as “new technologies”, “sleep disturbances”, “relationship between”, and “effects of new technology use on sleep quality”, we found that the results were unsatisfactory, as most articles did not relate these variables. Thus, to improve the search, an advanced search was

conducted, using English keywords: “impact”; “effect”; “influence”; “abuse of new technology”; and “sleep disorders.” The search engines returned 12,383 articles. After refining the results, we obtained 3,533 articles (Figure 1). The selection of articles was based on reading their abstracts and on the keyword search described previously, resulting in 38 articles selected that included at least one of the keywords used in the search.

After reading and analyzing the articles, 26 articles were selected that establish a relationship between the variables we intended to study. To make our analysis more coherent, the final selection of articles was made through discussion among group members about the content of the results presented and their relevance to this work. The result of this process was the final selection of 18 articles for analysis and discussion.

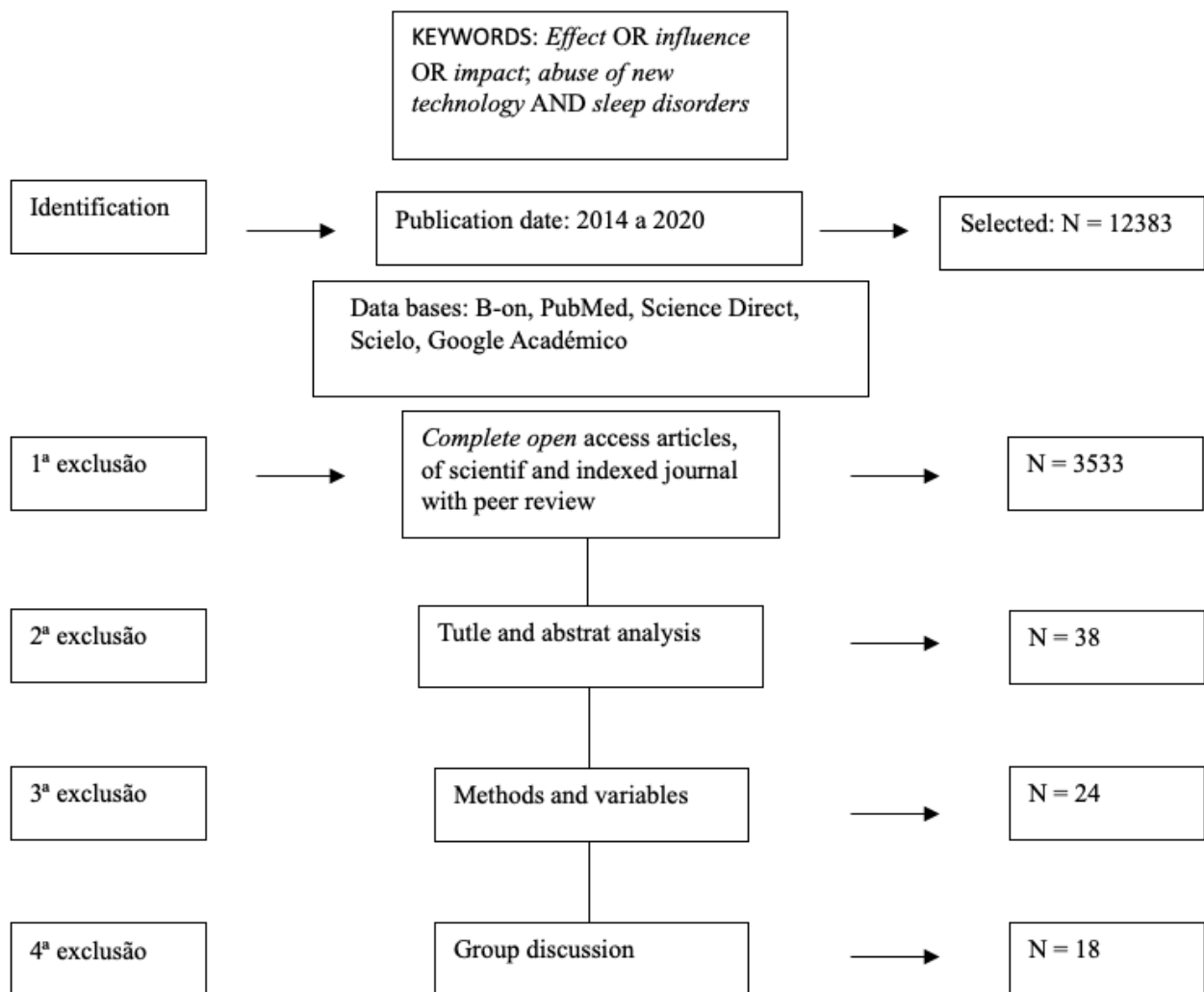


Figure 1: Flowchart.

RESULTS

Table 1: *Summary of results*

Authors and year	Objective	Variables	Results
Arora, E., Broglia, E., Thomas, G., & Taheri, S. (2014)	The impact of technology on sleep quality in a sample of young adolescents.	Weekday sleep duration; Technology use before bedtime on weekdays.	For those who usually/always used any type of technology, weekday sleep duration was significantly shorter than for those who sometimes/never used technology ($p < .05$).
Awasthi, S., Kaur, A., Solanki, H., Pamei, G., & Bhatt, M. (2020)	To assess smartphone use and its association with medical students' quality of life (QoL).	Quality of life and smartphone dependence; age; sex; parents' education and occupation; sociodemographic characteristics.	A total of 395 medical students were included; 42% considered themselves addicted to smartphones. According to the SAS-SV, smartphone addiction was found in 43.8% of medical students. The youngest and oldest cohorts were significantly less addicted to smartphones ($p < .001$). Male students were more addicted (OR = 1.45, CI = .962–2.174) compared with females. Students' QoL was significantly affected by smartphone use across all assessed domains (p ranging from $< .001$ to $.002$).
Bruni, O., Sette, S., Fontanesi, L., Baiocco, R., Laghi, F., & Baumgartner, E. (2015)	To analyze differences between preadolescents and adolescents in technology use and to test the contribution of Internet and mobile phone use and circadian preference to sleep quality.	Sleep habits; sex differences; time in bed; total sleep time; sleep-onset latency; number of Internet activities; number of mobile-phone activities; "timing off"; Internet use; smartphone use; sleep problems.	Preadolescent girls more often engaged in texting ($p < .01$), whereas preadolescent boys more often used game consoles ($p < .001$) and watched TV ($p < .05$). Adolescent girls used technology more consistently than boys—particularly social networks ($p < .001$), texting ($p < .001$), texting on social networks ($p < .01$), and music ($p < .001$)—while adolescent boys used game consoles ($p < .001$) and engaged in sports ($p < .001$) more after 9:00 pm.
Charmaraman, L., Richer, A. M., Ben-Joseph, E. P., & Klerman, E. B. (2020)	To investigate associations among social technology access and content, bedtime behaviors, parental phone restrictions, and sleep timing and duration on school nights in adolescents.	Social media use; Internet and mobile phone use; website/social media post content; behaviors one hour before bedtime; sleep duration; screen restrictions.	Social media and Internet use / sleep hours and bedtime: $R^2(.09; .11)$, respectively; problematic behaviors / sleep hours and bedtime: $R^2(.10; .10)$, respectively; fear of missing out / sleep hours and bedtime: $R^2(.10; .11)$, respectively; sleep loss due to Internet use / sleep hours and bedtime: $R^2(.20; .19)$, respectively; problematic digital technology use / sleep hours and bedtime: $R^2(.09; .09)$, respectively; texting frequency / sleep hours and bedtime: $R^2(.09; .10)$, respectively; age at receiving a smartphone / sleep hours and bedtime: $R^2(.10; .13)$, respectively. Behaviors one hour before bedtime: watching YouTube videos / sleep hours and bedtime: $R^2(.05; .04)$, respectively; texting friends: $R^2(.07; .05)$, respectively; checking social media / sleep hours and bedtime: $R^2(.07; .05)$, respectively; playing online games / sleep hours and bedtime: $R^2(.06; .04)$, respectively; reading a book / sleep hours and bedtime: $R^2(.05; .04)$, respectively; eating a snack / sleep hours and bedtime: $R^2(.05; .04)$, respectively.

Chen, Y., & Gau, S. S. (2016)	To evaluate bidirectional relationships between sleep problems and Internet addiction among children and adolescents.	Sleep problems: sleep duration; Internet addiction.	Students with Internet addiction, compared with those without Internet addiction, had 0.14 h (8.4 min) shorter nighttime sleep duration ($F = 5.61$, $p = .018$). No moderating effect ($p > .05$) was found for the longitudinal associations between sleep problems and Internet addiction, regardless of whether sleep problems predicted Internet addiction or Internet addiction predicted sleep problems.
Chindamo, S., Buja, A., DeBattisti, E., Terraneo, A., Marini, E., Perez, L. J. G., ... & Ceschin, F. (2019)	To unravel the association between new electronic devices and sleep problems in young children, considering other variables already known to be associated with sleep quality.	Total sleep time; sleep-onset latency; tablet and smartphone use.	17.8% of young children used tablets and smartphones sometimes (once or twice per week), 12.1% used them often (3 to 5 times per week), and 6.8% always (daily). Mean total sleep time was 11.81 h (± 1.03), with 9.97 h (± 0.99) nighttime sleep and 1.87 h (± 0.55) daytime sleep; mean sleep-onset latency was 28.9 min (± 15.60). Bedtime habits (sleep-onset latency and falling asleep with TV): $p < .001$; reading habits: $p = .009$; video games: $p = .005$; watching TV: $p = .121$; tablet or smartphone use: $p < .001$. Daily tablet or smartphone use increased the odds of shorter total sleep time ($p < .05$), and frequent (3–5 times/week) or daily use increased the odds of longer sleep-onset latency ($p < .05$ and $p < .05$), independent of other factors.
Ferreira, C., Ferreira, H., Vieira, M. J., Costeira, M., Branco, L., Dias, A., & Macedo, L. (2017)	To measure and characterize Internet use in adolescence, determine Internet dependence, and establish its association with sleep changes and excessive daytime sleepiness.	Internet use in adolescence; Internet dependence and sleep changes.	The results reiterate the prominent role of the Internet in adolescents' routines, who prioritize its use for accessing social networks and online games, and make these individual-use devices less susceptible to parental control.
Fuller, C., Lehman, E., Hicks, S., & Novick, M. (2017)	To explore electronic device use before bedtime and its impact on sleep quality and quantity, inattention, and body mass index.	Children's electronic use; sleep quantity and quality.	Children who watched TV at bedtime had 30 minutes less sleep than those who did not ($p = .025$). Children who used the phone at bedtime reported approximately 1 hour less sleep than those who did not ($p < .001$). Children who used a computer at bedtime reported approximately 60 minutes less sleep than those who did not ($p < .001$).
Genuneit, J., Brockmann, P., Schlarb, A., & Rothenbacher, D. (2017)	To investigate the association between media consumption (electronic media and books) and sleep quality in 3-year-old children; and the association between media consumption at age 3 and worsening sleep problems between ages 2 and 3.	Child sleep domains; children's electronic media consumption.	Watching TV or DVD was common, with screen time up to 1 h/day for 58.4% and >1 h/day for 13.7% of children. Computer games and other computer/Internet use were markedly less frequent and contributed less screen time. Associations were found between overall sleep quality and worsening indicators of bedtime resistance, sleep anxiety, and daytime sleepiness. The reported effects may have been partially driven by initiating electronic media consumption as a sleep aid.

Hacimusalar, Y., Hamamci, M., & Karaaslan, O. (2020)	To analyze levels of Internet addiction among people with and without sleep disorders and among those with good and poor sleep quality.	Internet addiction; sleep quality.	A positive correlation was found between sleep quality test scores and Internet addiction test scores: $p < .001$. Simple linear regression: sleep quality test scores predicted Internet addiction test scores (adjusted $R^2 = .092$; $p < .001$). Multiple linear regression: daytime dysfunction subscale scores (adjusted $R^2 = .154$; $p < .001$) and sleep disturbances (adjusted $R^2 = .022$; $p = .018$) affected Internet addiction test scores.
Hysing, M., Pallesen, S., Stormark, K. M., Jakobsen, R., Lundervold, A. J., & Sivertsen, B. (2015)	To investigate screen use during the day and electronic device use before bedtime in relation to sleep.	Sex; use of electronic devices; daytime use duration; bedtime; wake time; sleep-onset latency; wake after sleep onset.	Girls reported significantly more online instant messaging and PC use, while boys reported more console gaming and PC gaming (all $p < .001$). Use of PC, mobile phone, MP3 player, video game console, and TV in the hour before bedtime were all associated with higher odds of sleep deficiency. A dose-response relationship emerged, with higher risk of short sleep duration below 5 h (e.g., PC use and risk of <5 h sleep: OR = 2.70; 95% CI 2.14–3.39), while the risk for 7–8 h sleep was OR = 1.64 (95% CI 1.38–1.96). Daytime screen use showed a similar pattern. The risk of long sleep-onset latency (>60 min) was increased in adolescents using four or more devices compared with adolescents using only one device (OR = 1.26; 95% CI 1.07–1.49).
Lange, K., Cohrs, S., Skarupke, C., Gorke, M., Szagun, B., & Schlack, R. (2017)	To evaluate associations between time spent using different electronic media and insomnia complaints.	Daily time spent on each type of electronic social media and insomnia complaints.	Among boys, 4.2% reported insomnia complaints, and among girls, 7.4%. Computer/Internet use >3 h/day was strongly associated with insomnia complaints. Total screen time was associated with insomnia complaints in the >8 h/day category.
Levenson, J. C., Shensa, A., Sidani, J. E., Colditz, J. B., & Primack, B. A. (2016)	The effect of social media use on sleep disturbances in young adults.	Volume of social media use; frequency of social media use; sleep disturbances.	Mean volume was 61 min/day (IQR = 30, 135; range = 0–1447), while mean frequency was 30 visits/week (IQR = 8.5, 56.5; range = 0–385). 42.6% were in the low sleep-disturbance group, 28.0% in the medium group, and 29.4% in the high group. Participants with higher volume of social media use had significantly higher prevalence of sleep disturbances (all $p < .001$).
Lima, D., Kluthcovsky, A., Fernandes, L., & Okarenski, G. (2019)	To assess sleep quality and its association with computer and mobile phone use in medical and dentistry students.	Sleep quality; computer use; mobile phone use.	Poor sleep quality: 61.4% of medical students; 60.1% of dentistry students. Medicine: there was a difference in mean computer use time at night ($p = .04$) and computer ($p < .001$) and mobile phone ($p < .001$) use immediately before sleep. Dentistry: mean computer use immediately before sleep ($p = .03$) was higher among those with poor sleep quality. Considering only students with poor sleep quality, dentistry students showed greater mobile phone use over 24 h ($p < .001$) and at night ($p < .001$), while medical students showed greater computer use over 24 h ($p = .01$) and immediately before sleep ($p = .01$).

Mazzer, K., Bauducco, S., Linton, S. J., & Boersma, K. (2018)	To explore the strength and direction of the relationship between sleep duration and time spent using technology over one year; specifically, whether adolescents in a general population who use more technology are at risk of insufficient sleep duration and/or whether adolescents who report short sleep duration are more likely to engage in greater technology time one year later.	Sex; age; time spent using technology; sleep duration.	Boys reported significantly longer sleep duration than girls in 8th grade (boys: $M = 8\text{h } 13\text{ min}$, $SD = 3\text{min}$; girls: $M = 7\text{h } 44\text{ min}$, $SD = 3\text{min}$). As expected developmentally, both sexes showed a decline in sleep duration through 10th grade, where there was no longer a gender difference. Technology use duration was consistent over the year ($p < .001$). Boys and girls reported an average of 4–5 h/day on weekdays spent using technology. Correlations indicated that sleep duration and technology time were moderately correlated over time ($r = .46$, $p < .01$ and $r = .52$, $p < .01$, respectively).
Olashore, A., Akanni, O., & Ayilara, O. (2020)	To determine the prevalence of poor sleep quality (PSQ) in students, identify sociodemographic factors associated with PSQ, and examine how independent associations of psychological distress, stimulant use, and Internet use relate to PSQ.	Poor sleep quality (PSQ) and sociodemographic factors, Internet and stimulant use.	Participants were 174 (46.2%) males and 203 (53.8%) females aged 10–21 years. Mean age was 14.78 years. PSQ prevalence was 12.2%. A logistic regression model indicated that anxiety ($AOR = 1.20$, 95% $CI: 1.10\text{--}1.32$), depression ($AOR = 1.12$, 95% $CI: 1.00\text{--}1.25$), and Internet use ($AOR = 1.02$, 95% $CI: 1.00\text{--}1.03$) were associated with PSQ. PSQ commonly occurs among students and is related to their psychological state and potentially addictive behaviors such as Internet use. The authors prescribe optimal treatment of psychological disorders and addictive behavior, of which sleep problems are a typical consequence.
Vernon, L., Modecki, K., & Barber, B. (2017)	To examine the change in problematic social media investment and sleep disturbance.	Problematic social media use; sleep disturbances.	Problematic social media use was positively associated with sleep disturbances. Students with higher initial levels of problematic social media use tended to have higher initial levels of sleep disturbances—direct effects between constructs: problematic use and sleep disturbances— $CI = [.21, .33]$, $B = .27$, $\beta = .41$, $p < .05$. Problematic social media use increased from 9th to 11th grade, thereby increasing sleep disturbance—changes in constructs: problematic social media use and sleep disturbances— $CI = [.07, .37]$, $B = .19$, $\beta = .30$, $p < .05$.

Zhu, R., Fang, H., Chen, M., Hu, X., Cao, Y., Yang, F., & Xia, K. (2020)	To examine the potential non-linear association between time spent on different electronic devices and sleep disturbances, including the shape of the association and the risk threshold; (2) to explore whether the association differed by sex and weekday/weekend; and (3) to compare the effects of portable and non-portable devices.	Screen time; sleep disturbance; age; sex; recent illness history; smoking and parents' education; residential distance from a main road.	Sleep disturbance prevalence was 17.33% for boys and 16.81% for girls, with no statistically significant difference ($p = .79$). Compared with children without sleep disturbance, children with sleep disturbance appeared to spend more time watching TV, using computers, iPads, and mobile phones, but a statistically significant difference was found only for mobile phone use ($p = .03$). A dose-response association was observed between screen time and sleep disturbance; risk increased with more TV viewing time. For each 1 h/day increment above the threshold, sleep disturbance risk in all children increased by 12.35% (95% CI: 1.87%, 23.92%). The basic model suggested that sleep disturbance risk increased by 26.60% (95% CI: -2.67%, 64.67%) for computers, 5.16% (95% CI: -10.22%, 23.18%) for iPads, and 9.59% (95% CI: -4.59%, 25.88%) for mobile phones. The increase in sleep disturbance risk was significant among girls (95% CI: .44%, 32.57%), but not significant among boys (95% CI).
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DISCUSSION

After careful analysis of the articles, we found that, in general, technological advancement carries negative consequences for individuals' sleep quality. It has been noted that internet use significantly influences sleep quality; however, the mechanisms underlying the relationship between poor sleep quality and internet use remain poorly understood (Olashore et al., 2020). Nevertheless, there are some theories, such as the stimulating effect on the central nervous system from using electronic devices such as tablets, computers, and mobile phones (Ferreira et al., 2017) or internet games before sleep, the emission of light from these devices and their suppressive effect on melatonin release, or even the use of the Internet as a way of coping with sleep difficulties without seeking professional help, which can trigger some psychological disturbance (Olashore et al., 2020). As Chang et al. (2015) found, the use of these light-emitting devices before sleep (varying in intensity and duration) when projected onto the retina can inhibit melatonin secretion. These biological effects can perpetuate sleep deficiency and disrupt the circadian rhythm cycle, with consequences for performance, health, and safety.

Computer or internet use for more than 3 hours per day is strongly associated with insomnia complaints (Lange et al., 2017). Frequent use of technology before sleep was associated with a reduction in sleep duration. Thus, the frequency of technology use, rather than its amount, appears to be more harmful in adolescents (Arora et al., 2014). Problematic internet use has been reported as a cause of insomnia, poor sleep quality, and other sleep-related problems (Lin et al., 2019) and can be used as a way of coping with sleep difficulties in those with poor sleep quality, and as a consequence, may develop internet addiction (Hacimusalar et al., 2020). It was also possible to verify that internet addiction is associated with decreased sleep duration at night, increased sleep need, and circadian rhythm disturbance, predicted prospectively; internet use addiction was also predicted based on discrepancies during the follow-up period. Furthermore, it leads to irregular sleep patterns due to irregular sleep schedules (Chen & Gau, 2016).

Internet use, exposure to screen light, computer use, mobile phone use, and video game use are associated with later bedtimes, while good sleep hygiene is associated with

shorter sleep latency. Although not all electronic devices are associated with fewer sleep hours, caution in use is necessary to minimize the impact on sleep. In this context, recent epidemiological data on adolescent sleep show that it is characterized, on average, by late sleep time, a long latency to sleep onset, and a short sleep duration of approximately 6.5 hours on weekdays, contributing to a daily sleep deficit of about 2 hours. The mechanisms responsible for the relationships between the use of electronic social communication devices and sleep problems are not well established, but a theoretical model of the relationship has been proposed (Cain & Gradisar, 2010; Hysing et al., 2015), suggesting several possible mechanisms (Hysing et al., 2015). According to this model, the use of social media can directly affect sleep by replacing it due to its time-consuming nature, or it can interfere with sleep by increasing psychophysiological arousal caused by the stimulating content of the material or by exposure to bright light inherent in most electronic devices; in this way, bright light can impact sleep in two ways: by delaying the circadian rhythm when exposure occurs at night, or also by causing immediate activation (Hysing et al., 2015).

Another mechanism by which electronic media can impair sleep is physical discomfort, such as muscle pain and headaches, which can be caused by prolonged use (for example, computer games). Furthermore, their repeated use in bed or in the bedroom can reduce their sleep-inducing properties, as the bed and bedroom become associated with electronic device use (Hysing et al., 2015).

In this sense, Levenson et al. (2016) found that associations with sleep disturbances were greater for the frequency of use of these social communication media than for total use time, which may indicate that frequency of use is a better predictor of difficulty falling asleep than total time spent using these social communi-

cation media in general.

The study by Lima, Kluthcovsky et al. (2019) showed that health course students who had poor sleep quality used computers and mobile phones more immediately before sleep. The use of these electronic devices proves that it affects sleep quality, especially when used shortly before bedtime (Lima et al., 2019). It was concluded that there is a significant association between dissatisfaction in different domains of quality of life and smartphone dependency. This can be justified by the interference these devices cause in sleep quality, as well as by their effect on making life more stressful and lonely (Awasthi et al., 2020). Internet dependency and problematic use can significantly affect the sleep-wake cycle. Previous studies have reported an association among insomnia, irregular sleep patterns, daytime sleepiness, and excessive internet use (Ferreira et al., 2017). Also, the study by Genuneit et al. (2018) concluded that there are alarming associations between overall sleep quality and declines in sleep resistance indicators, sleep anxiety, and daytime sleepiness.

The study by Chindamo et al. (2019) demonstrates that total sleep time (nighttime and daytime) and sleep latency are associated with the use of touchscreen devices (tablets and smartphones), with most children beginning to use technology in their early years. On the other hand, the same author confirms that social media use is associated with unsatisfactory sleep in children. These devices introduced a new type of exposure, as they can be used anywhere, at any time, inside and outside the home, including at night and in the bedroom. In this way, children who have these portable devices in their bedroom may delay bedtime to play games or watch videos (Chindamo et al., 2019).

Also, the study by Fuller et al. (2017) suggests that children who watch television before sleep sleep about 30 minutes less

per night; however, those who use a mobile phone or computer before sleep sleep about 60 minutes less than those who watch television. Increased television time was associated with reduced total sleep time, later bedtime, delayed sleep onset, difficulties initiating sleep, difficulties maintaining sleep, reduced sleep efficiency, and daytime sleepiness in adolescents (Lange et al., 2017).

Already in 2015, Hysing and colleagues described that most adolescents report using one or more electronic devices at bedtime, with their use being significantly and positively associated with time to fall asleep and sleep deficiency, with an inverse dose-response relationship between sleep duration and use of social media. This study also shows that daytime and nighttime use of electronic devices influences various sleep parameters. Although the frequency of use differs across devices, the relationship between devices and sleep remains significant, suggesting that the relationship between television viewing and sleep, found in previous studies, may generalize to newer technologies (Hysing et al., 2015). Thus, Hysing et al. (2015) found that associations between the use of electronic social media and sleep were robust across all included sleep parameters, extending previous findings on the relationship between these media and time in bed.

Sleep need varies among individuals, and it can be argued that adolescents with lower sleep need may spend more time with electronic devices than those with greater sleep need (Hysing et al., 2015). Still, according to the same authors, there was a strong relationship between electronic device use and subjective sleep deficiency, indicating that its use is associated with sleeping less than they, and some experts, consider necessary.

Another relevant aspect in the follow-up of this topic was the conclusion of a 2020 study by Zhu and colleagues, who reported a positive but nonlinear relationship between time

spent watching television and sleep disturbances in preschool-aged children. It can be concluded from this study that increased time using electronic devices leads to an increase in sleep-related problems in children; furthermore, they found that the risk of sleep disturbances began to increase above the threshold of 1 hour per day, which is a much lower threshold than the standard (2 hours per day) often adopted in previous studies. It may be more beneficial for children's sleep to limit television viewing time to less than 1 hour per day, regardless of gender and day of the week/weekend (Zhu et al., 2020). The authors concluded that adolescents' average sleep hours are 7.5 per night, which is insufficient according to the National Sleep Foundation recommendations.

The results of Mazzer et al. (2018) emphasize the previous idea by describing a reciprocal association between sleep duration and technology use time; that is, not only does increased time spent with technology become associated with shorter sleep duration in the future, but also reduced sleep duration is related to greater technology use time. Although these results may contrast with others, in that sleep problems were found in young adults, not in relation to sleep duration or time spent with technology. These discrepancies may be due to the association between sleep duration and time dedicated to technological change as adolescents enter adulthood. Thus, young adults may not spend as much time with technology as adolescents do, but instead, when they cannot sleep, may actively choose to engage in activities to pass the time, in the same way as they would to pass the time during the day, which in this modern society typically involves at least one form of technology, whether a smartphone, social media, browsing the Internet (movies, series, music, etc.) or gaming (Mazzer et al., 2018).

Another issue, taken from another study by Bruni et al. (2015), concerns evening circadian

preference, with mobile phone and internet use, as well as performing other activities after 9 p.m., negatively influencing sleep quality, with late shutdown times and the number of devices in the bedroom also negatively influencing sleep quality. Unlike previous studies, this study allowed a comparison between preadolescents and adolescents, showing that after 9 p.m., adolescents were more frequently engaged in Internet and mobile phone activities, while preadolescents were more frequently engaged in video games (Bruni et al., 2015). Sleep quality was affected differently in the two age groups: in adolescents, smartphone use and number of devices, while in preadolescents, internet use and shutdown time were associated with sleep problems. Furthermore, differences between sexes were found in technology use after 9:00 p.m. (Bruni et al., 2015). Preadolescent females frequently engage in mobile phone text messaging, while males are more engaged with gaming consoles and television. In general, adolescent females used technology more consistently than males, mainly regarding social networks and music, while adolescents used more video game consoles and played sports after 9 p.m.; in this group of preadolescents and adolescents, there were reports of the presence of four or more electronic social communication devices (television, computer, console, mobile phone) in the bedroom; this has been linked to delays in bedtime, shorter sleep duration, greater resistance to bedtime, and higher levels of sleep disturbance (Bruni et al., 2015).

The study conducted by Vernon et al. (2017) revealed that problematic social media use is positively associated with sleep disturbances; that is, participants who showed high initial levels of problematic social media use tended to be more predisposed to developing a sleep disturbance or aggravating an existing one. These findings corroborate the idea that using interactive social communication devices can lead to poorer sleep quality and, in

some cases, sleep disturbance.

Another important factor in this topic was studied by Hacimusalar and colleagues (2020), who discovered that internet addiction test results were higher in participants who presented poor sleep quality than in those with good sleep quality; sleep quality test scores were able to predict internet addiction test results, which may mean that there is a relationship between levels of internet addiction and sleep quality, in which one can be the cause and the other the consequence.

CONCLUSION

After reviewing the literature, we were able to briefly and concisely answer the research question and achieve the objectives we set out to accomplish. Since our question focuses on the effect of new technologies on the prevalence of sleep disturbances, the results, in general, suggest that the analyzed studies pointed to a higher incidence of sleep disturbances with the use of technological devices such as mobile phones, tablets, and computers, among others. We also conclude that the use of these devices begins early, already in children, and that their use, both during the day and at night, or close to bedtime, reduces hours of sleep during the night, prolongs the time to fall asleep, and wakes up later in the morning, among other sleep-related problems.

Despite this, studies on this topic remain very scarce, leading us to conclude that further research is needed in this area.

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