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REVISÃO
REVIEW

Use of digital screens by adolescents and association on sleep quality: a systematic review

Uso de telas digitais por adolescentes e associação com a qualidade do sono: uma revisão sistemática

Uso de pantallas digitales por adolescentes y asociación con la calidad del sueño: una revisión sistemática

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Abstract

This study aimed to analyze the influence of digital screen use on adolescents' quality of sleep. This systematic review was recorded on PROSPERO (CRD42020203403) and conducted according to PRISMA guidelines. Studies covering adolescents from 10 to 19 years were included without language or publication restrictions which answered the following guiding question: "Does the use of digital screen influence adolescents' quality sleep?". Article search included the following databases: (MEDLINE/PubMed), LILACS, SciELO, Scopus, EMBASE, Web of Science, IBECS, Cochrane Library, ClinicalTrials.gov, and Open Gray. The following descriptors were used: "Sleep Quality", "Screen Time", and "Adolescent". The Newcastle-Ottawa Scale *(NOS) assessed the methodological quality of the cohort studies, and a modified NOS was used to assess the cross-sectional ones. In total, 2,268 articles were retrieved, of which 2,059 were selected for title and abstract reading, after duplicates were deleted. After this stage, 47 articles were selected for full reading, resulting in the 23 articles which compose this review. Excessive use of digital screens was associated with worse and shorter sleep, showing, as its main consequences, night awakenings, long sleep latency, and daytime sleepiness. The use of mobile phones before bedtime was associated with poor quality of sleep among adolescents. Our evaluation of the methodological quality of the chosen studies found seven to be poor and 16, moderate.*

Sleep Quality; Screen Time; Adolescent; Internet

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Introduction

In adolescence, the period between 10 and 19 years of age [1], important changes take place in individuals' sleep/wake cycle patterns, including a delay in the sleep phase, characterized by later sleeping and waking times. Sleep acts as an important component of physical growth and biological and mental development, considered a source of revitalization of organic functions associated with health indicators [2]. Moreover, proper sleep stimulates the immune system, helping it to fight infections and can thus reduce the risk of diseases [3,4,5].

According to the National Sleep Foundation (NSF; United States) [6], sleep should last for nine hours per night for adolescents to have optimal good health and development. However, research indicates that many teenagers sleep for less hours than appropriate. A study conducted in Brazil with 177 adolescents aged 12 to 19 years showed an average duration of 7.7 hours during the week [7]. Another, conducted with 524 Lebanese students, found an average sleep duration of 6.9 hours on weekdays [8]. In South Korea, 1,796 adolescents reported sleeping only 6.4 hours on school days [9].

Among adolescents, digital screen viewing is common. These activities can take up more than 14 hours a day [3]. Increasing the time spent viewing television sets, computers, mobile phones, and various types of portable digital screens can damage adolescents' health, causing, for example, poor quality of sleep [10,11,12,13,14].

In recent decades, the use of digital screens has changed how young people interact and acquire knowledge. As with cell phones, 75% of adolescents use them to access social media, online games, streaming services, and applications [15,16,17]. Therefore, it is important to highlight that screen time is their most common sedentary behavior, consisting of the time spent playing video games, using cell phones, tablets, computers, and/or watching television [15].

Excessive use of digital screens can both impair sleep and reduce physical well-being among adolescents due to headaches, tinnitus, stomach pain, musculoskeletal pain, or high body mass index, among others [16,17]. Similarly, increased use of these digital screens is associated with a higher likelihood of social isolation, suicidal thoughts, self-mutilation, peer victimization, and mental health problems among adolescents [18].

Therefore, this systematic review aimed to verify the relation between the use of digital screens and adolescents' sleep quality.

Methodology

This systematic review was registered on PROSPERO (protocol n. CRD42020203403) and was conducted according to PRISMA guidelines. Our clinical issue consisted of the question: "Does the time spent on digital screens influence the quality of adolescent sleep?" (P = adolescents; I = excessive use of digital displays; C = low use of digital displays; O = poor quality of sleep).

Eligibility criteria

Studies which evaluated screen usage time and sleep duration and quality among adolescents were included in this review. No restriction to date of publication, language, and study design were set but adolescents from 10 to 19 years of age were included, according to the World Health Organization (WHO) classification [1]. Case reports or series, letters to editors, literature reviews, theses, and dissertations were excluded.

Search strategy

The available articles from the following databases were included: MEDLINE/PubMed, LILACS, SciELO, Scopus, EMBASE, Web of Science, IBECS, Cochrane Library, ClinicalTrials.gov, and Open Gray.

The following descriptors were used in our advanced search: "Sleep Quality", "Screen Time", and "Adolescent" and their synonyms recognized by the Medical Subject Headings (MeSH) and Health

Sciences Descriptors (DeCS) glossaries. Our search strategy used was: "Sleep Quality [MeSH Terms]) OR Sleep OR Sleep Disorders OR Quality) AND Screen Time [MeSH Terms]) OR Screen Times OR Digital) AND Adolescent [MeSH Terms]) OR Adolescents) OR Adolescence) OR Teens) OR Teenagers) OR Teenagers) OR Teenager) AND Youths) OR Youth". This strategy was adapted to each database, based on their specificities.

A manual search was also performed in the references of the selected articles and in some journals on the topic, such as *Sleep & Breathing*, *Journal of Clinical Sleep Medicine*, *Journal of Sleep Research*, *Nature and Science of Sleep*, *Sleep Medicine*, and *Sleep Health*.

Articles were independently chosen by two trained and calibrated researchers (S.S.S. and M.A.C.S.). Disagreements were solved by a third reviewer (M.V.H.) via discussions and consensus. The corresponding author was contacted if studies lacked data or additional information was needed.

Methodological evaluation of the chosen studies

Article quality was assessed by the *Newcastle-Ottawa Scale* (NOS) [19]. NOS was used for cohort studies and the modified NOS for cross-sectional ones. These scales assess bias via three aspects: participant selection (generalization and applicability); group comparability; and outcome evaluation.

The NOS for cohort and transverse studies is composed of eight and six items, respectively. Each item can receive a point (one star), except for the second aspect "Comparability", whose score ranges from zero to two stars. Study bias risk may receive a maximum score of nine stars for cohort studies and seven, for cross-sectional ones. Cohort studies with nine stars are considered good; six to eight stars, moderate; and those with five stars or less, poor. Cross-sectional studies with a seven-star rating are considered good; between four and six, moderate; and those with three stars or less, poor [20].

The methodological quality of the studies was assessed by two independent reviewers (S.S.S. and M.A.C.S.) who were previously trained and calibrated with a 0.91 inter-rater kappa. Disagreements were solved by a third reviewer (M.V.H.) via discussions and consensus.

Results

Initially, we found 2,268 articles, of which we excluded 209 as duplicates, totaling 2,059 articles for title and abstract reading. After this phase, we chose 47 articles for a complete textual analysis. We excluded 24 studies since they failed to meet our inclusion criteria, leaving the 23 studies we included in this systematic review (Figure 1).

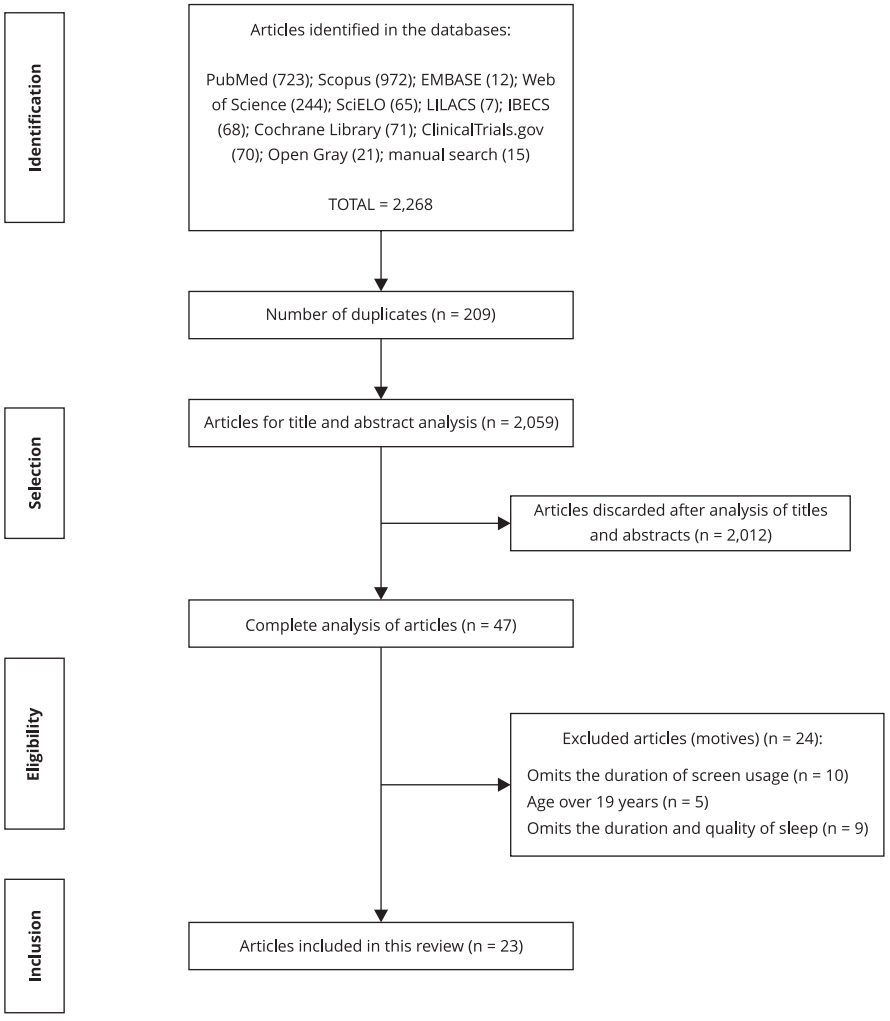
As for temporal distribution, 21.73% of studies took place between 2010-2015; 33.43%, in 2017; 8.69%, in 2018; 26.08%, in 2019; and 13.04%, in 2020. We found no studies for 2016. As for their geographical distribution, 39,13% of the studies was conducted in Europe; 34.78%, in Asia; 13.04%, in South America; 8.69%, in North America; and 4.34%, in Oceania. Regarding their study design, 20 were transversal, and three, cohort. We found no randomized clinical or case-control trials.

Table 1 summarizes the chosen studies on the use of digital screens and sleep quality, highlighting their authors, year, country of origin, type of study, sample, screen use duration, sleep quality, association between screen time and sleep quality, and the consequences of excessive screen use.

Tables 2 and 3 show our bias risk assessment according to the cohort-specific NOS score and its version adapted for cross-sectional studies, respectively. Of the 23 studies included, we considered seven as poor (three cohort and four cross-sectional studies) and 16, as moderate (all cross-sectional studies).

Figure 1

Identification of the final sample.



Discussion

This systematic review aimed to verify the relation between digital screen use and adolescents' sleep quality. Our results indicates that digital screen use at bedtime was associated with poor sleep quality, shorter sleep duration, and greater daytime sleepiness [5,7,11,21,22]. Our findings support recommendations suggesting that interventions be developed and evaluated to reduce access to digital screens at bedtime [5,7,11,14,21,22,23].

We considered the three cohort studies evaluated by the NOS (Table 2) as poor [24,25,26] due to their incomplete sample data description and absent cohort monitoring, showing more than 20% of loss or incomplete description thereof. Moreover, it we found selection and information biases, confounding factors, and undescribed result importance and its applicability in clinical practice.

We considered the quality of the studies included in the modified NOS as moderate [3,5,7,9,10,11,12,13,14,21,22,23,27,28,29] (Table 3). Their limitations include non-validated measurement instruments [28,29,30,31],

Table 1

Description of articles according to author, year, location, age group, sample, study design, and results.

Authors (year)	Country	Study type	Sample	Screen usage duration	Sleep duration	Influence of screen time on sleep quality	Consequence of excessive screen usage	Study quality (stars)
Munezawa et al. [21] (2011)	Japan	Cross-sectional study	94,777 adolescents aged 13 to 19 years	Use of mobile phone after switching off lights (> 2h per night)	Insufficient (between 6h and 7h per day)	Associated with poor sleep quality with screen time ($p < 0.01$)	Insomnia, daytime sleepiness, and short sleep duration	★★★★★
Falbe et al. [32] (2014)	United States	Cross-sectional study	2,048 adolescents with an average age of 10.6±1.5 years	TV or DVD (2.4±1.9/day); computer or video games (1.8±1.8/day)	Sufficient (> 8h a day)	Sleeping near small screens and sleeping with TVs in their bedrooms were associated with 37.0 minutes (95%CI: 20.1-53.9; $p < 0.001$) and 31.1 minutes (95%CI: 19.1-43.1; $p < 0.001$) of late bedtime, respectively	Later sleep and perception of rest or insufficient sleep	★★
Mak et al. [3] (2014)	China	Cross-sectional study	762 adolescents with an average age of 15.27±1.70 years	Computers (3h26min/day); TV (2h50min/day); mobile phone (2h18min/day); portable video devices (1h3min/day). Total: 5h54min/day when using screens	Insufficient (< 8h per day)	Length of cell phone use increases the risk of poor sleep quality (95%CI: 0.033-0.170; $p < 0.01$)	Daytime sleepiness and musculoskeletal pain	★★★★★
Aguilar et al. [22] (2015)	Chile	Cross-sectional study	196 girls with an average age of 12.2 years	TV (1h56min/day); video games (27min/day); computer (1h79min/day). Total: 2h43min/day	Sufficient (9h25min per night)	The longer the screen time (≥ 2h/day) the lower the quality of sleep (95%CI: 3.05-3.93; $p < 0.001$)	Overweight and obesity	★★★★
Wu et al. [10] (2015)	China	Cross-sectional study	4,747 adolescents with an average age of 19.22 years	Screen usage greater than 2h/day	Poor quality of sleep reported in 9.8% of its sample	Association between high screen time and poor sleep quality (OR = 1.32, 95%CI: 1.06-1.65; $p < 0.001$)	Symptoms of anxiety, depression, and psychopathology	★★★★★
Amra et al. [11] (2017)	Iran	Cross-sectional study	2,257 adolescents with average age of 15.44±1.55 years	Phone usage after 21h for more than 2h	Insufficient (7h34min per day)	Regression model shows that adolescents who used mobile phones at night were 1.39 times more likely to have poor quality of sleep than those who did not ($p < 0.001$)	Increased sleep latency	★★★★

(continues)

Table 1 (continued)

Authors (year)	Country	Study type	Sample	Screen usage duration	Sleep duration	Influence of screen time on sleep quality	Consequence of excessive screen usage	Study quality (stars)
Chung et al. [9] (2017)	South Korea	Cross-sectional study	1,796 adolescents with an average age of 14.9±1.8 years	Use of smartphones (between 3h and 5h/day)	Insufficient (6.4±1.7h)	It showed that girls tend to use social media (SMS) and messaging services more often than boys (41.2 vs. 26.5% and 23.6 vs. 12.8%, respectively, p < 0.0001 for both)	Daytime drowsiness for both genders and females	★★★★★
Hawi et al. [8] (2017)	Lebanon	Cross-sectional study	524 adolescents with an average age of 16.2 years	Average playing time was 2.2h/day	Insufficient (6.9±1.7h)	Hierarchical multiple regression showed that excessive use of online games (> 2h a day) is associated with lower age (-3.032; p < 0.001) and shorter sleep duration (-2.766; p < 0.001)	Lower academic performance	★★★
Husarova et al. [29] (2017)	Slovakia	Cross-sectional study	7,595 adolescents aged 11 to 15.9 years	Internet usage (> 2h/day) and playing video games (> 2h/day)	Insufficient (< 8h per day)	Time spent on digital screens was associated with shorter sleep duration (95%CI: 0.15-0.28; p < 0.01), and higher prevalence of sleep problems (95%CI: 0.12-0.31; p < 0.01)	Reduction of sleep hours and school problems	★★★★★★
Jun et al. [27] (2017)	South Korea	Cross-sectional study	249 adolescents aged 17 to 19 years	Computer (1.3h±0.7/day); TV (0.7h±0.7/day); mobile cell phones (1.5h±0.7/day); games (0.5h±0.7/day)	Insufficient (6.9h per day)	Association between the use of mobile phones before sleeping and poor quality of sleep (95%CI: 1.83-2.52; p < 0.05)	Reduction of hours of sleep and daytime sleepiness	★★★★
Royant-Parola et al. [30] (2017)	France	Cross-sectional study	776 adolescents with a mean age of 12.4±1.2 years	Tablet, cell phones, and computers (use between 1h to 2h/day)	Insufficient (< 6h)	Shorter sleep with the use of computers (67% vs. 33%; p < 0.0001), mobile phones, (99% vs. 80%; p = 0.0001) and smartphones (85% vs. 66%; p = 0.0001) in their rooms	Negative effect on mood; difficulty waking; irritability; night awakening; feelings of sadness, and sleep deprivation	★★★
Silva et al. [23] (2017)	Brazil	Cross-sectional study	481 adolescents aged 14 to 19 years	Cell phone and TV usage greater than 2h/day	Insufficient (< 8h per day)	Quality of sleep was associated with insufficient sleep time (PR = 2.69; 95%CI: 1.53-4.69; p < 0.001) and excessive TV time (PR = 1.49; 95%CI: 1.03-2.16; p < 0.001)	Bruxism; sleep walking; sleep talking; nightmares one or more times a week; frightened and/or terrified awakenings	★★★★★

(continues)

Table 1 (continued)

Authors (year)	Country	Study type	Sample	Screen usage duration	Sleep duration	Influence of screen time on sleep quality	Consequence of excessive screen usage	Study quality (stars)
Akçay et al. [31] (2018)	Turkey	Cross-sectional study	392 adolescents with an average age of 16.04±0.86 years	6.78±5.10 hours per day (TV, mobile phones, and games)	Insufficient (7h05min±1.51)	The greater the use of digital screen, the greater the awakening time of adolescents' sleep	Does not report	★★★
Cabré-Riera et al. [12] (2018)	Spain	Cross-sectional study	258 adolescents aged 17 to 18 years	Use of mobile phones, tablets, laptops, video games, and TVs for a total time of 3h04min (1h37min-4h38min)	Insufficient (6:18-7:11)	Cell phone use was associated with lower quality of sleep (PR = 1.55; 95%CI: 1.03-2.33; p < 0.001)	Increased standby time	★★★★★★
Adelantado-Renau et al. [33] (2019)	Spain	Cross-sectional study	269 adolescents with an average age of 13.9±0.3 years	Evaluation in minutes/day: Internet (53.3±58.5), cell phones (111.0±84.3), TV (90.9±52.9), and video game usage (34.5±44.0)	Sufficient (> 8h per day)	The quality of sleep was negatively associated with the use of video games (-0.150), time of Internet use (-0.179) and mobile phones (-0.131)	Decreased thinking ability and lower overall cognitive performance	★★★★
Caumo et al. [7] (2019)	Brazil	Cross-sectional study	177 adolescents with an average age of 13.69±1.78	TV (2.25h/day); tablet (2h/day); mobile phone (4h/day)	Insufficient (7.76±1.72)	Statistically significant association between the use of cell phones at night and worse quality of sleep during the week (95%CI, 0.22-0.29; p < 0.001) and weekends (95%CI: 0.19-0.22; p < 0.001)	Reduction of sleep hours	★★★★
Foerster et al. [29] (2019)	Switzer-land	Cohort	843 adolescents aged 13 to 15 years	TV, computer, laptop, tablet and mobile phone use totaled an average screen time of > 2h/day	Insufficient (< 8h/day)	The longer the screen time, the lower the quality of sleep [OR = 2.11 (95%CI: 1.11-4.02); adjusted OR = 2.64 (95%CI: 1.33-5.26)]	Night awakenings	★★★★★
Hisler et al. [25] (2019)	United Kingdom	Cohort	11,361 adolescents with an average age of 13,777	Access to social media (between 1h and 2h/day); Internet (3h to 5h/day); games (between 1h and 2h/day); TV (between 2h and 3h/day)	Insufficient (< 8h/day)	Excessive use of digital screens is related to negative sleep results, mainly in the use of Internet for more than 2h/day (OR = 3.55; 95%CI: 2.74-4.61; p < 0.001).	Reduction of sleep hours; night awakenings; and long sleep latency	★★★★

(continues)

Table 1 (continued)

Authors (year)	Country	Study type	Sample	Screen usage duration	Sleep duration	Influence of screen time on sleep quality	Consequence of excessive screen usage	Study quality (stars)
Mireku et al. [5] (2019)	United Kingdom	Cross-sectional study	6,816 adolescents with an average age of 12.1 years for boys and 12.0 years for girls	Mobile phone usage after dark. Article does not describe the duration	Sufficient (8.8h per night)	Night-time use of mobile phones and television was associated with higher chances of insufficient sleep on weekdays (OR = 1.82; 95%CI: 1.59-2.07 and OR = 1.40; 95%CI: 1.23-1.60)	Difficulty falling asleep, sleeping poorly, and waking up frequently during the night	★★★★★
Scott et al. [13] (2019)	United Kingdom	Cross-sectional study	11,872 adolescents aged 13 to 15 years	Social media usage (> 5h/day)	Insufficient (less than 8h/day)	Intense use of social media was associated with late (OR = 2.75; 95%CI: 2.38-3.18; p < 0.001) and poor sleep (OR = 2.11; 95%CI: 1.75-2.55; p < 0.001)	Night awakening	★★★★★
Hrafnkelsdottir et al. [14] (2020)	Iceland	Cross-sectional study	247 adolescents with an average age of 15.8 years	Video games (1.0h±1.3h/day); Internet (2.2h±1.3h/day); TV (1.7h±0.9h/day)	Insufficient (7.5±0.7)	Screen time, especially for playing, was associated with poor quality of sleep (b = 3.813; SE = 1.010 p < 0.001)	Night awakening and reduction of hours of sleep and rest	★★★★
McManus et al. [24] (2020)	United States	Cohort	98 adolescents with an average age of 16.2 years	Use of screen-based media with little or no interaction (videos, TV, computer and web browsing): 13h per week. Media interaction screen (video game, instant message, e-mail): 16h per week. Total: 33.5h per week	Insufficient (7.15h of sleep)	Association of interactive screen time with lower sleep quality at a 3-month follow-up (β = -0.25, p = 0.06). Three-month assessment: simple tilt analyses showed that longer interactive screen time was associated with better sleep quality for men (β = -0.48, p < 0.01), but not for women (β = 0.24, p = 0.27)	Depressive symptomatology and worse sleep quality	★★★★★

(continues)

Table 1 (continued)

Authors (year)	Country	Study type	Sample	Screen usage duration	Sleep duration	Influence of screen time on sleep quality	Consequence of excessive screen usage	Study quality (stars)
Smith et al. [26] (2020)	New Zealand	Cross-sectional study	4,811 adolescents from 13 to 17 years old	Use of digital screens for more than 2h a day ($p < 0.001$)	Insufficient (< 8h in 39% of participants)	The most common screen activities before bedtime were social media (88%) and texting/instant messaging (77%). Most participants reported using phones in bed (86%) and "agreed" they spend a lot of time on screens (70%), a perception that increased with age ($p = 0.008$)	Use of screens harms health, socialization, and schoolwork	★★★★★★

95%CI: 95% confidence interval; aOR: adjusted odds ratio; b: non-standard regression coefficient; OR: odds ratio; PR: prevalence ratio; SE: standard error.

Table 2

Evaluation of the quality of cohort studies on the relation between sleep quality and use of digital screens in adolescents, based on the *Newcastle-Ottawa Scale*.

	Hisler et al. [25]	Foerster et al. [29]	McManus et al. [24]
Selection			
Sample representativeness	a ★	a ★	a ★
Sample selection	c	c	c
Exposure determination	b ★	b ★	b ★
Comparability			
Comparability of cohorts based on design or analysis	b ★★	b ★★	b ★★
Outcome			
Outcome evaluation	c	c	c
Follow-up was long enough for results to occur	b	a ★	a ★
Suitability of cohort follow-up	c	c	c
Total score (maximum: 9 stars)	★★★★	★★★★★	★★★★★

Selection (maximum: 4 stars): 1) Representativeness of the exposed cohort: (a) truly representative of average individuals in the community ★; (b) somewhat representative of average individuals in the community ★; (c) selected group of users; and (d) no description of cohort derivation. 2) Selection of the unexposed cohort: (a) extracted from the same community as the exposed group ★; (b) extracted from a different source; and (c) no description of the derivation of the unexposed group. 3) Determination of exposure: (a) secure record ★; (b) structured interview or questionnaire ★; (c) written self-report; and (d) no description. 4) Demonstration that the result of interest was absent at the start of the study: (a) yes ★; (b) no.
Comparability (maximum: 2 stars): 1) Comparability of cohorts based on design or analysis: (a) study of the control for a confounding variable ★; (b) control study for two or more confounding variables ★★.
Outcome (maximum: 3 stars): 1) Evaluation of the result: (a) independent blind evaluation ★; (b) record binding ★; (c) self-reporting; and (d) no description. 2) Follow-up was long enough for results to occur: (a) yes (please select a monitoring period appropriate to the outcome of interest) ★; (b) no. 3) Adequacy of cohort monitoring: (a) complete follow-up – all individuals represented ★; (b) individuals lost to follow-up are likely to have no ≤ 20% loss bias or ≥ 80% follow-up or the provided description of those lost ★; (c) ≥ 20% loss or ≤ 80% follow-up or no description of the lost; and (d) no statement.

Table 3

Evaluation of the methodological quality of cross-sectional studies based on the modified *Newcastle-Ottawa Scale*.

Authors (year)	Selection			Comparability	Outcome		Total score (maximum: 7 stars)
	Sample representativeness	Non-respondents	Exposure determination	Comparability	Outcome evaluation	Statistical test	
Mak et al. [3] (2014)	a ★	a ★	a ★	a ★	c	a ★	★★★★★
Jun et al. [27] (2017)	a ★	a ★	a ★	c	c	a ★	★★★★
Husarova et al. [28] (2017)	a ★	a ★	b	ab ★★	b ★	a ★	★★★★★★
Caumo et al. [7] (2019)	a ★	c	a ★	a ★	c	a ★	★★★★
Hawi et al. [8] (2017)	a ★	c	a ★	c	c	a ★	★★★
Hrafnkelsdottir et al. [14] (2020)	a ★	c	a ★	a ★	c	a ★	★★★★
Wu et al. [10] (2015)	a ★	c	a ★	ab ★★	c	a ★	★★★★★
Mireku et al. [5] (2019)	a ★	c	a ★	ab ★★	c	a ★	★★★★★
Royant-Parola et al. [30] (2017)	a ★	c	b	a ★	c	a ★	★★★
Aguilar et al. [22] (2015)	a ★	c	a ★	c	c	a ★	★★★★
Silva et al. [23] (2017)	a ★	b	a ★	a ★	c	a ★	★★★★★
Falbe et al. [32] (2014)	a ★	c	a ★	c	c	b	★★
Chung et al. [9] (2017)	a ★	b	a ★	ab ★★	c	a ★	★★★★★
Scott et al. [13] (2019)	a ★	b	a ★	ab ★★	c	a ★	★★★★★
Cabré-Riera et al. [12] (2018)	a ★	b	a ★	ab ★★	b ★	a ★	★★★★★★
Munezawa et al. [21] (2011)	a ★	c	a ★	ab ★★	c	a ★	★★★★★
Amra et al. [11] (2017)	a ★	a ★	a ★	c	c	a ★	★★★★
Adelantado-Renau et al. [33] (2019)	a ★	c	a ★	ab ★★	c	b	★★★★
Akçay et al. [31] (2018)	a ★	b	b	a ★	b ★	b	★★★
Smith et al. [26] (2020)	a ★	a ★	b	ab ★★	b ★	a ★	★★★★★★

Selection (maximum: 3 stars): 1) Representativeness of the sample: (a) Truly representative of the mean in the target population ★ (all subjects or random sampling); (b) Unrepresentative of the mean in the target population (non-random sampling) ★; (c) Selected user group; and (d) No description of the sampling strategy. 2) Non-respondents: (a) Comparability between the characteristics of respondents and non-respondents is established and the response rate is satisfactory ★; (b) Response rate is unsatisfactory or comparability between respondents and non-respondents is unsatisfactory; and (c) No description of response rate or characteristics of responders and non-respondents. 3) Determination of exposure: (a) Validated measuring instrument (e.g., independent blind evaluation using clinical indices by calibrated examiners) ★; (b) Measuring instrument not validated but available or described; and (c) No description of measuring instrument.

Comparability (maximum: 2 stars): 1) Confounding factors are controlled: (a) The study controls socioeconomic condition ★; (b) Study control for any additional factor ★; and (c) No description related to adjustment analysis for confounding factors.

Outcome (maximum: 2 stars): 1) Determination of outcomes: (a) Independent blind assessment ★; (b) Record binding ★; (c) Self reporting; and (d) No description. 2) Statistical test: (a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is shown, including confidence intervals and their significance level (p-value) ★; (b) The statistical test is inappropriate, undescribed or incomplete.

the fact that only three studies performed inferential analyses [12,24,26], and lack of adjustment analysis for confounding factors [8,11,22,27,32].

We observed differences in the results of the analyzed studies. We believed that the low and moderate quality of their scientific evidence is due to disparities in their methodological and sampling criteria. Moreover, studies proved to be heterogeneous due to factors related to socioeconomic status [3,27]; local cultural issues [5,11,12,23]; questionnaire type, associated to different digital screen types [5,8,9,32]; and time analysis of answers [3,14,21].

Only four studies (out of 23) found sufficient sleep duration in their samples [5,22,32,33]. The literature reports that inadequate sleep duration leads to lower performance in social and school activities and greater daytime sleepiness in adolescents [8,28,33]. These findings indicate that access to and use of digital screens at bedtime damages individuals' health, causing low immunity, heart diseases, and reduced longevity, among others [22]. Moreover, we also found, in the study by McManus et al. [24], an association of poor sleep quality with symptoms of depression.

The studies by Hisler et al. [25] and Jun et al. [27] showed a 4h30 and 4h40 daily use of digital screens (TV, mobile phones, video games, and computers), respectively. Scott et al. [13] verified a daily use of digital screens greater than 5h per day. Mak et al. [3] highlighted that adolescents spent 5h54min/day on digital screens. Among the limitations of the mentioned studies is their lack of description of the time of day at which individuals used screens.

Many factors lead to poor sleep quality in adolescents, ranging from biological factors (such as maturation changes) to environmental factors (such as family life, caffeine consumption, and use of electronic devices) [13]. Among young people, poor quality of sleep may be associated with its insufficient duration [10,14,25,26,28,31] which, in turn, may be related to biological and maturational factors, behavioral and social changes, increased school obligations, social activities, and excessive use of electronic equipment [14,25,26,28,31]. Note that bedtime changes appear to be greater in adolescents than in other age groups [25]. The literature has suggested that stressful (and sometimes annoying) media content may be an underlying factor of how mobile phone use can affect sleep [14].

A large proportion of adolescents ignore the adverse effects of the use of digital screens, such as mobile phones, in bed [5]. They mistakenly believe that these media can help them sleep since they associate digital screens with their personal routine. However, using digital screens at bedtime can delay the onset of sleep. Some adolescents report finding it hard to turn off social media to sleep [13].

Among all the digital screens the studies evaluated, cell phones are the most associated with poor sleep quality [3,5,7,9,11,12,21,27,30,31] due to their ease of access and practicality. The study by Munezawa et al. [21] pointed out that using a mobile phone after switching off the lights (> 2h a night) to make calls or send text messages is associated with poor quality of sleep among adolescents. It is important to highlight how school schedules influence adolescents' sleep duration and the conflict with the use of screens at night [34] since the excessive use of screens compromises school routine and sleep duration [26,31].

Melatonin is a hormone produced by our body which regulates the circadian rhythm. The study by Cabré-Riera et al. [12] describes that refraining from using digital screens at least one hour before going to sleep is ideal for good sleep, as the light from the screen reduces the production of melatonin and gives the brain a false sensation that it is still day. Moreover, time spent on digital screens can replace time which might be devoted to study, which, together with worse sleep, can result in lower academic performance [8,28,33]. For a good sleep regimen, individuals need to stipulate an hour to sleep and wake and promote a silent environment with low light and away from electronic devices [5,20].

Smith et al. [26] identified interventions to limit the use of screens to improve sleep in adolescents. Silent mode, turning theme off, time restrictions, no screens in bedrooms, screenless nights, and parent-set bedtime effectively restricted screen usage and improved sleep quality in adolescents, especially younger ones.

Mobile phone use and online browsing increase physical and emotional arousal, which could interfere with sleep quality [23]. Note that, besides cell phones, television is one of the digital screens adolescents most use [5,23,26,31,32], especially at night, followed by electronic games, which are more used by boys [8,33].

It is important to point out that the excessive use of digital screens generates consequences which affect adolescents' quality of life, such as: night awakening [13,14,30,34]; daytime sleepiness [3,9,21,27]; anxiety, depression, psychopathology, sadness, irritability, and mood swings [10,30]; and bruxism [23].

We also point out that the use of cell phones can cause musculoskeletal pain in adolescents' thoracolumbar region and back, caused by incorrect posture, inadequate furniture or prolonged use of screens while sitting [3,35]. Adolescents may experience neck pain due to overload by head tilt during device use [35].

Poor sleep, associated with the excessive use of digital screens, has been closely related to adverse effects on the cognitive processes of the prefrontal cortex, which can negatively influence operational memory and the executive function of the brain [33]. Moreover, poor sleep reduces daytime alertness, the ability to learn new information in school, and hinder sports, driving, and working which, in turn, can affect attention and lead to adolescents' lower performance on social activities [8,24,28,33].

Due to the evolution of technology and the replacement of textbooks by media devices in schools, the access and use of digital screens increased, especially due to the COVID-19 pandemic. We are unable to ignore the impacts of the COVID-19 pandemic, which emerged in China in late 2019 and spread rapidly around the world [36].

Changes in the pattern of daily activity (as due to the COVID-19 pandemic), have further increased time spent with digital screens. This new condition caused several changes in lifestyle, physical and mental health, and relationships [37]. Measures of social isolation, school closing, linked to stress and anxiety made adolescents more vulnerable to excessive exposure to screens [38]. A Polish study found that the percentage of children and adolescents who spend more than six hours a day watching TV and using the Internet increased from 1.3% to 5.1%, influencing the quality of how they spend their hours [39].

Another study conducted with immunosuppressed and healthy adolescents aged 10-18 years confirmed the increased use of meshes by both groups during the pandemic [40], corroborating the findings of Zhou et al. [41], who studied healthy adolescents and young adults aged 12-29 years old, who showed increased cell phone screen use and worse sleep quality, prolonged sleep latency, and shorter sleep duration.

We should emphasize that adolescents have a greater need for sleep than adults [25], in addition to the occurrence of a natural delay in the time of sleep onset. Before the pandemic, adolescents followed a usual routine, with face-to-face classes and set times, which reduced the use of screens during school activities. After the pandemic, adolescents were able to make the schedule of their classes more flexible and adapt it to their sleep preferences. Online classes starting later, social distancing, changes in the class system (use of screens), and the pressure of confinement motivated a shift in sleep habits and quality [42].

We found that the excessive use of digital screens has negatively affected these adolescents' lives. The increased use of these devices at bedtime negatively affects the relation between sleep and rest, stimulating physiological processes such as the suppression of melatonin release, a sleep-inducing hormone, and providing psychological changes, such as high levels of anxiety and depression [12]. Shorted sleep affects school and family routines. Thus, establishing a sleep regimen in adolescents' routines is essential to improve their quality of sleep and, consequently, their lives.

Limitations

The limitations of this study relate to most included studies showing cross-sectional designs, which precludes the assessment of cause-and-effect relations. Moreover, we observed some methodological limitations, such as undescribed sample losses and team calibration. Furthermore, the lack of standardization in the data collection methods of the chosen studies, such as sleep duration and screen use, hindered our comparisons.

Conclusion

This systematic review could verify that the use of digital screens influences sleep quality and can generate consequences which affect adolescents' quality of life. The analyzed studies showed that adolescents' show insufficient sleep duration (less than eight hours per day) and that the main digital screens used before sleeping are cell phones, televisions, computers, and video games. Excessive use of digital screens can bring some consequences, such as daytime sleepiness, night awakenings, difficulty waking, poor school performance, irritability, anxiety, depression, feelings of sadness, and sleep deprivation.

Contributors

S. S. Silva, M. A. C. Silveira, H. C. R. Almeida, M. C. P. Nascimento, and M. A. M. Santos contributed to the study design, data analysis and interpretation, and writing. M. V. Heimer contributed to the data analysis and interpretation and writing. All the authors approved the final version of the manuscript. S. S. Silva is also the guarantor of the study, responsible for its integrity as a whole, from its inception to its publication.

Additional informations

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Conflict of interests

The authors explicitly state that there are no conflicts of interest.

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Resumo

Este estudo buscou analisar a influência do uso de telas digitais na qualidade do sono de adolescentes. Esta revisão sistemática foi registrada no PROSPERO (CRD42020203403) e realizada de acordo com as diretrizes do PRISMA. Foram incluídos estudos que abrangem a faixa etária de 10 a 19 anos sem restrição de idioma ou data de publicação e que responderam à seguinte pergunta condutora: "O uso da tela digital influencia a qualidade do sono dos adolescentes?". A busca por artigos incluiu as seguintes bases de dados: (MEDLINE/PubMed), LILACS, SciELO, Scopus, EMBASE, Web of Science, IBECS, Cochrane Library, ClinicalTrials.gov e Open Gray. Os descritores utilizados foram "Qualidade do Sono", "Tempo de Tela" e "Adolescente". A Escala de Newcastle-Ottawa *(NOS) foi utilizada para avaliar a qualidade metodológica dos estudos de coorte e a escala NOS modificada foi usada para avaliar os estudos transversais. Foram encontrados 2.268 artigos, dos quais 2.059 foram selecionados para leitura de títulos e resumos após a exclusão das duplicatas. Foram então selecionados 47 artigos para leitura na íntegra, dos quais 23 foram escolhidos para compor esta revisão. O uso excessivo de telas digitais foi associado à má qualidade e menor duração do sono, apresentando como principais consequências despertares noturnos, maior latência do sono e sonolência diurna. Ademais, o uso do celular antes de dormir foi associado à má qualidade do sono em adolescentes. A avaliação da qualidade metodológica classificou sete estudos como sendo de baixa qualidade e 16 de qualidade moderada. Concluímos que o uso de telas digitais influenciou a qualidade do sono dos adolescentes.*

Qualidade do Sono; Tempo de Tela; Adolescente; Internet

Resumen

Este estudio buscó analizar la influencia del uso de pantallas digitales en la calidad del sueño de los adolescentes. Esta revisión sistemática se registró en PROSPERO (CRD42020203403) y se realizó de acuerdo con los lineamientos de PRISMA. Se incluyeron los estudios en que participaron el grupo etario entre los 10 y los 19 años, sin restricción de idioma o fecha de publicación, y que respondieran a la siguiente pregunta orientadora: "¿El uso de la pantalla digital influye en la calidad del sueño de los adolescentes?". La búsqueda de artículos se realizó en las siguientes bases de datos: (MEDLINE/PubMed), LILACS, SciELO, Scopus, EMBASE, Web of Science, IBECS, Cochrane Library, ClinicalTrials.gov y Open Gray. Los descriptores utilizados fueron "Calidad del sueño", "Tiempo de pantalla" y "Adolescente". Se utilizaron la Escala Newcastle-Ottawa *(NOS) para evaluar la calidad metodológica de los estudios de cohortes y la NOS modificada para evaluar los estudios transversales. Del total de 2.268 artículos encontrados, se seleccionaron 2.059 para la lectura de títulos y resúmenes después de excluidos los duplicados. Luego se seleccionaron 47 artículos para lectura completa, de los cuales 23 fueron elegidos para componer esta revisión. El uso excesivo de las pantallas digitales estuvo asociado con la mala calidad y menor duración del sueño, teniendo como principal consecuencia los despertares nocturnos, el aumento de la latencia del sueño y la somnolencia diurna. Además, el uso del teléfono celular antes de acostarse se asoció con una mala calidad del sueño en los adolescentes. La evaluación de la calidad metodológica clasificó siete estudios como de baja calidad y 16 como de calidad moderada. Se concluyó que el uso de las pantallas digitales influye en la calidad del sueño de los adolescentes.*

Calidad del Sueño; Tiempo de Pantalla; Adolescente; Internet

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