Original Article

# Sleep hygiene practices and its impact on sleep quality and mood

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## Abstract

**Introduction:** Shift in circadian clock of adolescence with delayed bedtime and early awakening to catch morning school effects their sleep. Present study elucidated sleep hygiene practices of school-going adolescents and explored its association with their sleep quality and mood. **Methods:** Students of 6th to 12th grade were enrolled after requisite permissions, parental consent, and written informed assent from students. Standardized questionnaires were used to evaluate for sleep hygiene practices-Adolescent Sleep Hygiene Scale (ASHS), sleep quality- Pittsburgh Sleep Quality Index (PSQI), daytime sleepiness-Pediatric Daytime Sleepiness Scale (PDSS) and mood (DASS-21-Depression Anxiety Stress Scale-21). CTRI/2022/06/043556 is the study number in Clinical Trial Registry of India. **Results:** Adolescents with mean age 14.28 ± 1.86 years, including 48.7% (479) males and 51.2% (503) females participated in this study. Mean sleep hygiene score was 4.37 ± 0.60, with no difference between males and females. On ASHS subscales comparison, females had poorer sleep quality (0.009), higher daytime sleepiness ($P$ = 0.001), poorer cognitive/emotional factor ($P$ = 0.001) and higher depression, anxiety, and stress (DASS-21). Young adolescents (10–14 years; N = 528) had better total sleep hygiene scores ($P$ = 0.016), better bedtime routine, cognitive/emotional factor ($P$ = 0.001), but had poor sleep environment factor ($P$ = 0.001). Younger adolescents also exhibited better quality of sleep ($P$ = 0.003), lesser daytime sleepiness, and lesser mood derangements compared to older adolescents (15–19 years; N = 453). Sleep hygiene scores showed a significantly negative correlation with mood and sleep quality. **Conclusion:** A clear relationship between sleep hygiene practices, mood and sleep quality has been observed among adolescents. Young adolescents who followed better sleep hygiene practices had lesser mood derangements and better sleep quality. Though ASHS scores were same among both genders but females had poor sleep quality, higher daytime sleepiness and mood.

**Keywords:** Adolescents sleep hygiene practices, adolescents sleep quality, ASHS and daytime sleepiness, sleep hygiene and sleep quality, sleep quality and mood

## Introduction

Adequate sleep is essential for physical growth, psycho-social advancement, emotional regulation, cognition as well as learning.[1,2] It is vital for maintaining a hormonal balance as well as repairing and restoring the body system. Sleep hygiene is "a set of behavioral and environmental recommendations intended to promote healthy sleep," and plays a crucial role in maintenance of overall physical and psychological health.[3] It includes maintaining consistent bedtimes/rise times; curbing light and sound levels; optimizing body and room temperature; refraining from caffeine consumption before bedtime; as well as keeping a healthy diet and fitness routine.[4]

The transition from childhood to adulthood during adolescence involves not only physical changes but also creates mental pressure regarding career planning. Sleep deprivation is prevalent

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among adolescents resulting from both natural shifts in their sleep pattern as well as increased late-night device usage, along with early school start timings. This leads teenagers, trying to "catch up" sleep on weekends and thus disturbing their circadian rhythm.[5,6] An extra hour of evening technology use has been shown to increase the odds of poor sleep efficiency by 20%.[5] Stress as well as low socioeconomic status have been shown to have negative influence on sleep hygiene of adolescents.[7] Researchers have reported that 65% of adolescents experience daytime sleepiness and have at least one poor sleep hygiene habit like studying in bed, staying up late, and/or engaging in chatting on mobile phones or watching television.[8] Galland *et al.* have shown affected arousal factors, sleep stability factors, and cognitive-emotional factors among adolescent girls with disturbed and poor sleep quality and Good sleep hygiene has been shown to have a positive association with high sleep quality.[9-11]

Though, several studies on adolescents' sleep hygiene have been conducted but they have either failed to encompass the full range of habits that impact sleep health or have been conducted on a small population. Comprehensive research in this area including the broader spectrum of sleep hygiene factors, addressing a larger adolescent population will help in identifying the major common poor sleep hygiene practices among adolescents. The present study explored the prevalent sleep hygiene practices among adolescents and its association with their sleep quality and mood.

## Material and Methods

### Study design

A cross-sectional study was conducted among adolescent students in grades 6$^{th}$ to 12$^{th}$. A list of eligible schools was acquired, and subsequent selection of schools was done using a computerized random number generator. The study was in accordance with the principles of Declaration of Helsinki. Ethical permission to conduct study was duly obtained from the institutional ethics committee. Requisite permissions were obtained from the respective school administrations, and the students of grades 6$^{th}$ to 12$^{th}$ from eligible schools were invited to participate. The study is registered as CTRI/2022/06/043556 in the Clinical Trial Registry India.

### Procedure

Students were introduced to the study and those giving assent for participation and who submitted parental consent were enrolled in the study. Standardized questionnaires were used to ask about their sleep hygiene practices, sleep quality and mood. Explanations were provided in a readily comprehensible manner for each item of questionnaires. Students with epilepsy, attention deficit hyperactive disorder (ADHD) and/or chronic pulmonary disease, or those on any other chronic medication were excluded from the study.

Questionnaires used to obtain requisite details from the students are-

### Adolescent Sleep Hygiene Scale (ASHS)[11]

ASHS is a 32-item self-reported inventory, which evaluates on a six-point Likert Scale. The scale is anchored with "Never" assigned a score of 1, followed by "once in a while" =2, "sometimes" =3, "Quiet Often" =4, "Frequently, if not always" =5, lastly "Always" scoring the highest score of six. It provides eight subscale scores, including physiological factor, behavioral arousal factor, cognitive/emotional factor, sleep environment factor, sleep stability factor, daytime sleep factor, substances factor, and bedtime routine factor, in addition to an overall sleep hygiene score. Higher scores mean better sleep hygiene score.[11] Overall sleep hygiene score was calculated as a mean score of all subscales.

### Pittsburgh Sleep Quality Index (PSQI)[12]

PSQI evaluates various aspects of an individual's sleep patterns over the past month. It is validated among adolescents and has 19 items grouped into seven distinct component scores.[13] Each item is evaluated using a four-point Likert scale of 0 to 3 and sum of seven items gives a Global PSQI score ranging from 0 to 21. Higher PSQI scores indicate a greater degree of sleep disturbance and poorer sleep quality.[12]

### Pediatric Daytime Sleepiness Scale (PDSS)[14]

PDSS is a self-reported questionnaire that assesses daytime sleepiness in adolescents of school age, and scores range from 0 to 32. Elevated PDSS scores connotate amplified daytime sleepiness.[14] Values >26 for 6$^{th}$ and 7$^{th}$ grade and >30 for 8$^{th}$ grade is considered abnormal.[15]

### Depression Anxiety Stress Scale-21 (DASS-21)[16]

DASS-21 is a 21-item scale for assessment of negative emotional state and is validated among adolescents.[17] It consists of seven items each for exploring levels of depression, anxiety, and stress.[16] All items are graded on a 0–3 Likert scale. A total of seven items each for depression, anxiety, and stress scores are summarized to assess the levels of respective emotional states. A cut-off level of >10 for depression, >8 for anxiety, and >15 for stress is used to classify further as normal, mild, moderate, severe, or extremely severe.[18]

### Statistical method

Data was recorded in Microsoft Excel, and the statistical analysis was conducted using Statistical Package for Social Sciences version 22 (SPSS, Inc., Chicago, IL, USA). Descriptive data was presented using mean ± SD for continuous variables and percentage (N) for categorical variables. Independent-sample t-tests were employed to compare differences between groups. Spearman correlation analysis was performed to assess the relationship between two numerical variables. All statistical tests used a two-tailed confidence interval of 95% ($\alpha = 2$) and a significance level of $P < 0.05$ to determine statistical significance.

## Result

Our study evaluated sleep quality, mood, and status of sleep hygiene practices among 982 school-going adolescents with a mean age of 14.28 ± 1.86 years. 48.7% (479) males and 51.2% (503) females participated in this study. Mean sleep hygiene score was 4.37 ± 0.60, with no difference between male and female participants [Table 1]. However, on comparison of individual ASHS subscales, females had lower daytime sleepiness factor on ASHS ($P$ = 0.001) and higher PDSS scores ($P$ = 0.002), both suggesting an increased daytime sleepiness among females. They were poorer on cognitive/emotional factor ($P$ = 0.001), while males had poorer scores on substances factor ($P$ = 0.006). Sleep quality was poorer among females ($P$ = 0.009), who experienced greater depression, anxiety, and stress.

**Table 1: Comparison of sleep quality, Mood, daytime sleepiness and sleep hygiene scores among male and female adolescents**

| Variables | Total ($n$=982) | Male ($n$=479) | Female ($n$=503) | $P$ |
|---|---|---|---|---|
| ASHS Subscales | | | | |
| Physiological Factor[a] | 4.29±0.98 | 4.23±1.02 | 4.35±0.94 | 0.062 |
| Behavioural Arousal Factor[a] | 3.92±1.30 | 3.93±1.27 | 3.91±1.32 | 0.753 |
| Cognitive/Emotional Factor[a] | 3.97±1.08 | 4.09±1.03 | 3.85±1.12 | 0.001* |
| Sleep Environment Factor[a] | 4.87±1.02 | 4.82±1.05 | 4.92±0.99 | 0.1 |
| Sleep stability Factor[a] | 4.08±1.42 | 4.13±1.48 | 4.02±1.36 | 0.241 |
| Daytime Sleepiness Factor[a] | 4.68±1.17 | 4.81±1.15 | 4.56±1.17 | 0.001* |
| Substances Factor[a] | 5.77±0.73 | 5.70±0.83 | 5.83±0.62 | 0.006* |
| Bedtime Routine Factor[a] | 3.40±1.91 | 3.31±1.94 | 3.48±1.89 | 0.166 |
| ASHS Total[a] | 4.37±0.62 | 4.38±0.64 | 4.37±0.60 | 0.76 |
| Sleep Quality (PSQI)[b] | 4.99±2.86 | 4.75±2.68 | 5.22±3.01 | 0.009* |
| Daytime Sleepiness (PDSS)[c] | 13.58±5.62 | 13.01±5.78 | 14.13±5.42 | 0.002* |
| Depression | 8.91±8.21 | 8.47±8.02 | 9.33±8.37 | 0.102 |
| Anxiety | 8.48±7.90 | 8.27±7.83 | 8.69±7.96 | 0.411 |
| Stress | 9.01±7.75 | 8.70±7.75 | 9.30±7.76 | 0.221 |

*$P$<0.05 is significant. [a]Higher score indicates better sleep hygiene. [b]Higher score indicates poor quality sleep. [c]Higher score indicates more sleepiness

On comparison of the young (age 10–14 years; N = 528), and older adolescents (ages 15–19 years; N = 454), categorized as per the WHO categorization it was evident that young adolescents had better total sleep hygiene score ($P$ = 0.016) with better bedtime routine, cognitive/emotional factor ($P$ = 0.001), however they were poorer on sleep environment factor ($P$ = 0.001) [Table 2].[19,20] Young adolescents exhibited better sleep quality ($P$ = 0.003), lesser daytime sleepiness, and lesser mood derangements ($P$ < 0.001).

Based on sleep quality scores students were grouped as poor sleepers (PSQI >5) and good sleepers (PSQI ≤5). Good sleepers (N = 600) exhibited higher scores in almost all domains of ASHS in addition to total ASHS score. Individuals with good sleep quality (PSQI ≤5) reported significantly lower levels of depression, anxiety, and stress compared to poor sleepers (N = 382) [Table 3].

To assess the most common behaviors that disrupted sleep hygiene, behavior/factor wise assessment was done as depicted in Table 4. Among the various sleep-disrupting behaviors, a substantial chunk of adolescents-72.1% (708)- reported "*thinking about things they need to do*" sometimes to always while going to bed. This was followed by 64.6% (634), who indulged in consumption of more than four glasses of liquid and 64.2% (630), who extended their sleep schedule beyond an hour on weekends. Additionally, 63.7% (625) were engaged in stimulating activities such as playing video games, watching TV, or conversing on mobile phones within an hour prior to bedtime; while 62.7% (616) mentally revisited the events of the day before falling asleep. [Table 4] 64.7% (635) practiced bedtime rituals such as brushing teeth, reading or bathing as a part of their night regimen and >90% had never smoked/chewed tobacco or consumed alcohol after 6 p.m. However, 6.8% (68) reported consuming alcohol, and 5.4% (54) adolescents admitted to smoking or chewing tobacco [Table 4].

ASHS score and its subscales showed a significantly negative correlation with mood and sleep quality [Table 5]. Correlation

**Table 2: Comparison of sleep hygiene, sleep quality, daytime sleepiness, and mood among young and older adolescents**

| Variables | Young Adolescents (10–14 years) ($n$=528) | Older Adolescents (>14–19 years) ($n$=453) | $P$ |
|---|---|---|---|
| ASHS Subscales | | | |
| Physiological Factor[a] | 4.29±0.97 | 4.31±0.98 | 0.758 |
| Behavioural Arousal Factor[a] | 3.92±1.32 | 3.92±1.27 | 0.948 |
| Cognitive/Emotional Factor[a] | 4.10±1.04 | 3.81±1.10 | <0.001* |
| Sleep Environment Factor[a] | 4.77±1.07 | 4.99±0.94 | 0.001* |
| Sleep stability Factor[a] | 4.13±1.42 | 4.02±1.42 | 0.254 |
| Daytime Sleepiness Factor[a] | 4.71±1.17 | 4.65±1.16 | 0.400 |
| Substances Factor[a] | 5.78±0.69 | 5.75±0.79 | 0.489 |
| Bedtime Routine Factor[a] | 3.64±1.90 | 3.13±1.90 | <0.001* |
| ASHS Total[a] | 4.42±0.64 | 4.32±0.59 | 0.016* |
| Sleep Quality (PSQI)[b] | 4.75±2.85 | 5.28±2.85 | 0.003* |
| Daytime Sleepiness (PDSS)[c] | 12.46±5.79 | 14.88±5.13 | <0.001* |
| Depression | 7.58±7.54 | 10.47±8.68 | <0.001* |
| Anxiety | 7.45±7.40 | 9.69±8.30 | <0.001* |
| Stress | 8.12±7.43 | 10.02±8.01 | <0.001* |

*$P$<0.05 is significant. [a]Higher score indicates better sleep hygiene. [b]Higher score indicates poor quality sleep. [c]Higher score indicates more sleepiness

**Table 3: Comparison of sleep hygiene practices and mood of adolescents with good (PSQI ≤5) and Bad Sleep (PSQI >5)**

| Variables | Good sleepers (PSQI ≤5) (*n*=600) | Poor sleepers (PSQI >5) (*n*=382) | *P* |
|---|---|---|---|
| Sleep Duration | 6:50±1:00 | 6:04±1:11 | <0.001* |
| Daytime Sleepiness (PDSS)[a] | 12.79±5.65 | 14.82±5.35 | <0.001* |
| ASHS Subscales | | | |
| Physiological Factor[b] | 4.40±0.96 | 4.13±0.99 | <0.001* |
| Behavioural Arousal Factor[b] | 4.00±1.31 | 3.79±1.27 | 0.015* |
| Cognitive/Emotional Factor[b] | 4.18±1.01 | 3.62±1.10 | <0.001* |
| Sleep Environment Factor[b] | 4.98±0.96 | 4.70±1.08 | <0.001* |
| Sleep stability Factor[b] | 4.17±1.41 | 3.93±1.42 | 0.009* |
| Daytime Sleepiness Factor[b] | 4.76±1.11 | 4.56±1.25 | 0.014* |
| Substances Factor[b] | 5.79±0.70 | 5.74±0.78 | 0.274 |
| Bedtime Routine Factor[b] | 3.48±1.93 | 3.28±1.89 | 0.118 |
| ASHS Total[a] | 4.47±0.59 | 4.22±0.64 | <0.001* |
| Depression | 5.86±5.92 | 13.71±8.98 | <0.001* |
| Anxiety | 5.65±5.89 | 12.93±8.58 | <0.001* |
| Stress | 6.16±6.22 | 13.47±7.83 | <0.001* |

*$P$<0.05 is significant. [a]Higher score indicates more sleepiness. [b]Higher score indicates better sleep hygiene

of individual PSQI components shows that sleep duration has a significantly positive correlation with emotional factor and sleep stability factor of ASHS scale. Reduction in any of the subscales of ASHS leads to increased sleep disturbances, daytime sleepiness as well as daytime dysfunction [Table 5].

## Discussion

The present study evaluated the frequency, at which school-going adolescents engage in sleep hygiene practices and explored its association with overall sleep quality and mood. Findings indicate that females experience poorer sleep quality and higher daytime sleepiness. Younger adolescents have better sleep hygiene practices and sleep quality. Adolescents having better sleep quality had longer sleep duration, fewer disturbances, and lower levels of depression, anxiety, and stress. The most prevalent sleep-harming behaviors included pre-sleep over-thinking and engaging in stimulating activities. Sleep quality, as well as mood both are associated with sleep hygiene routine practices. Poor sleep hygiene practices negatively affect mood as well as sleep quality and are primarily associated with increased sleep disturbances, daytime sleepiness, and dysfunction.

### Gender differences among sleep hygiene practices

Though, no significant differences were observed between males and females on overall sleep hygiene however, specific sleep hygiene subscales showed contrasting patterns with females scoring better on substance factors (refraining from smoking, chewing tobacco, or consuming alcohol), while males were better on cognitive and emotional factor (behaviors and negative emotional states at bedtime) and daytime sleepiness factor (avoid napping for longer than an hour or after 6 p.m.). Females have been shown to display better sleep hygiene behaviors in behavioral arousal, daytime sleep factor, and sleep stability domain in a study by Chehri *et al.*,[21] though in our study, daytime sleepiness was higher in females in both PDSS scale as well as ASHS. Females showed poor sleep quality and higher mood scores, suggesting a higher prevalence of negative thoughts and emotional distress before bedtime. Galland BC *et al.*[22] have also reported significant sleep disturbance among adolescent girls, affecting behavioral arousal factors, sleep stability factors, and cognitive-emotional factors of ASHS. The behavioral gender differences observed in our study could be due to the more emotional nature of females in general; additionally, physiologically, females attain early pubertal changes compared to males, though in this study we could not explore the pubertal stage of the participants.[23] Targeted educational interventions could be beneficial for addressing these factors especially, among adolescent girls who pass through an early physiological and emotional transition during adolescence as compared to their male counterparts.

### Sleep hygiene practices among young and old adolescents

Young adolescents had better sleep hygiene scores with significantly better scores on cognitive/emotional factor ($P \leq 0.001$) and bedtime routine factor ($P \leq 0.001$), however, young adolescents scored less on sleep environment factor (falling asleep, while watching TV; sleeping in a room that is too hot or cold etc.) [Table 2]. This may be because younger adolescents have less academic burden and experience more freedom for watching television or for sharing bed with parents and/or siblings. Noland *et al.*[24] too have reported that environmental factors such as watching television, improper bedroom temperature, and excessive noise are barriers for adequate sleep among high school students. Given the deteriorating sleep health and increasing academic pressure, especially among older adolescents, there is a pressing need to educate the students as well as parents to promote healthy sleep behavior to achieve a balance between academic rigor and adequate rest. Young adolescents had better sleep quality with less daytime sleepiness and better mood like previous studies.[25] An early sensitization of students at the stage of young adolescence would be beneficial to them in understanding the importance of sleep for their overall mental, physical, and academic well-being.

**Table 4: Frequency distribution of Adolescents (*n*=982) for various factors on ASHS scale**

| Variables | Always - Sometimes | Occasionally - Never |
|---|---|---|
| Physiological Factor | | |
| After 6 p.m., I have drinks with caffeine (e.g., cola, root beer, iced tea, coffee) | 37.98% (373) | 62.02% (609) |
| During the hour before bedtime, I am very active (e.g., playing outside, running, wrestling) | 62.53% (614) | 37.47% (368) |
| During the 1 hour before bedtime, I drink >4 glasses of water (or some other liquid) | 64.56% (634) | 35.44% (348) |
| I go to bed with stomach ache | 22.91% (225) | 77.09% (757) |
| I go to bed feeling hungry | 38.09% (374) | 61.91% (608) |
| Behavioural Arousal Factor | | |
| During the hour before bedtime, I do things that make me feel very awake (e.g., playing video games, watching TV, talking on the telephone) | 63.65% (625) | 36.35% (357) |
| I go to bed and do things in my bed that keep me awake (e.g., watching TV, reading) | 47.35% (465) | 52.65% (517) |
| I use my bed for things other than sleep (e.g., talking on the telephone, watching TV, playing video games, doing homework) | 59.67% (586) | 40.33% (396) |
| Cognitive/Emotional Factor | | |
| I go to bed and think about things I need to do | 72.10% (708) | 27.90% (274) |
| I go to bed and replay the day's events over and over in my mind | 62.73% (616) | 37.27% (366) |
| I check my clock several times during the night | 45.21% (444) | 54.79% (538) |
| During the 1 hour before bedtime, things happen that make me strong emotions (sadness, anger, excitement) | 56.52% (555) | 43.48% (427) |
| I go to bed feeling upset | 41.65% (409) | 58.35% (573) |
| I go to bed and worry about things happening at home or at school | 61.41% (603) | 38.59% (379) |
| Sleep Environment Factor | | |
| I fall asleep while listening to loud music | 25.66% (252) | 74.34% (730) |
| I fall asleep while watching TV | 37.17% (365) | 62.83% (617) |
| I fall asleep in brightly lit room (e.g., the overhead light is on) | 28.31% (278) | 71.69% (704) |
| I fall asleep in a room that feels too hot or too cold | 39.61% (389) | 60.39% (593) |
| I fall asleep in one place and then move to another place during night | 30.96% (304) | 69.04% (678) |
| Sleep stability Factor | | |
| During the school week, I stay up more than 1 hour past my usual bedtime | 47.66% (468) | 52.34% (514) |
| During the school week, I sleep in more than 1 hour past my usual wake time | 44.70% (439) | 55.30% (543) |
| At weekends, I stay up more than 1 hour past my usual bedtime | 59.06% (580) | 40.94% (402) |
| At weekends, I sleep in more than 1 hour past my usual wake time | 64.15% (630) | 35.85% (352) |
| Daytime Sleepiness Factor | | |
| During the day, I take a nap that lasts >1 hour | 42.67% (419) | 57.33% (563) |
| After 6 p.m., I take a nap | 30.35% (298) | 69.65% (648) |
| Substances Factor | | |

*Contd...*

**Table 4: Contd...**

| Variables | Always - Sometimes | Occasionally - Never |
|---|---|---|
| After 6 p.m., I smoke or chew tobacco | 5.50% (54) | 94.50% (928) |
| After 6 p.m., I drink beer (or other drinks with alcohol) | 6.92% (68) | 93.08% (914) |
| Bedtime Routine Factor | | |
| I use a bedtime routine (e.g., bathing, brushing teeth, reading) | 61.91% (608) | 38.09% (374) |

Sleep hygiene behavior from "Always" till "sometimes" has been clubbed in one and "Once a while" and "Never" another

**Table 5: Co-relation analysis of Sleep hygiene factors with mood, sleep quality and it's components**

| Sleep quality and Mood ASHS domains | PSQI *r* (*P*) | Sleep Duration *r* (*P*) | Sleep Disturbance *r* (*P*) | Sleep Onset Latency *r* (*P*) | Sleep Efficiency *r* (*P*) |
|---|---|---|---|---|---|
| Physiological Factor | −0.16 (<0.001*) | −0.001 (0.981) | −0.18 (<0.001*) | −0.119 (<0.001*) | 0.016 (0.612) |
| Behavioural Arousal Factor | −0.116 (<0.001*) | 0.036 (0.264) | −0.146 (<0.001*) | −0.05 (0.118) | 0.03 (0.35) |
| Cognitive/emotional factor | −0.293 (<0.001*) | 0.135 (<0.001*) | −0.255 (<0.001*) | −0.178 (<0.001*) | −0.101 (0.002*) |
| Sleep Environment Factor | −0.15 (<0.001*) | 0.043 (0.179) | −0.15 (<0.001*) | −0.11 (0.001*) | −0.021 (0.511) |
| Sleep stability Factor | −0.148 (<0.001*) | 0.131 (<0.001*) | −0.125 (<0.001*) | −0.135 (<0.001*) | −0.029 (0.369) |
| Daytime Sleepiness Factor | −0.109 (0.001*) | 0.034 (0.289) | −0.091 (0.004*) | −0.072 (0.024*) | −0.022 (0.495) |
| Substances Factor | −0.034 (0.293) | −0.004 (0.906) | −0.02 (0.53) | 0.022 (0.495) | 0.041 (0.201) |
| Bedtime Routine Factor | −0.071 (0.026*) | 0.04 (0.208) | −0.012 (0.705) | −0.012 (0.708) | −0.082 (0.010*) |
| ASHS Total | −0.257 (<0.001*) | 0.114 (<0.001*) | −0.214 (<0.001*) | −0.143 (<0.001*) | −0.058 (0.067) |
| **Sleep quality and Mood ASHS domains** | **Daytime Sleepiness (PDSS) *r* (*P*)** | **Daytime Dysfunction due to Sleepiness *r* (*P*)** | **Depression *r* (*P*)** | **Anxiety *r* (*P*)** | **Stress *r* (*P*)** |
| Physiological Factor | −0.112 (<0.001*) | −0.092 (0.004*) | −0.153 (<0.001*) | −0.228 (<0.001*) | −0.216 (<0.001*) |
| Behavioural Arousal Factor | −0.149 (<0.001*) | −0.112 (<0.001*) | −0.185 (<0.001*) | −0.201 (<0.001*) | −0.17 (<0.001*) |
| Cognitive/emotional factor | −0.244 (<0.001*) | −0.272 (<0.001*) | −0.398 (<0.001*) | −0.426 (<0.001*) | −0.389 (<0.001*) |
| Sleep Environment Factor | −0.103 (0.001*) | −0.067 (0.035*) | −0.171 (<0.001*) | −0.171 (<0.001*) | −0.171 (<0.001*) |
| Sleep stability Factor | −0.16 (<0.001*) | −0.12 (<0.001*) | −0.208 (<0.001*) | −0.189 (<0.001*) | −0.216 (<0.001*) |
| Daytime Sleepiness Factor | −0.16 (<0.001*) | −0.087 (0.007*) | −0.146 (<0.001*) | −0.146 (<0.001*) | −0.147 (<0.001*) |
| Substances Factor | −0.029 (0.365) | 0.043 (0.18) | 0.002 (0.942) | −0.023 (0.473) | −0.036 (0.254) |
| Bedtime Routine Factor | −0.124 (<0.001*) | −0.048 (0.133) | −0.069 (0.030*) | −0.086 (0.012*) | −0.059 (0.064*) |
| ASHS Total | −0.284 (<0.001*) | −0.179 (<0.001*) | −0.295 (<0.001*) | −0.323 (<0.001*) | −0.303 (<0.001*) |

*$P$<0.05 is significant

## Sleep hygiene practices among good and poor sleepers

Good sleepers (PSQI <5) had significantly better scores on all factors of sleep hygiene and mood indicating that adherence to sleep hygiene practices not only promotes better sleep quality but also improves mood [Table 3]. Older adolescents were more depressed, anxious, and stressed compared to younger adolescents. Similar findings have been reported by Singh *et al.*,[25] in their study where teenagers aged 13–15 years were more depressed in association to delayed bedtime, shorter sleep duration and poor academic performance compared to preteens aged 11–12 years. School sleep education programs could play an important role in addressing sleep disturbances at an early age, with an emphasis on sleep hygiene being as important as food hygiene for mental and physical well-being.

## Adolescents sleep hygiene practices and sleep quality

Overall, the adolescents were incompliant with sleep hygiene practices, with a total ASHS score of 4.37 ± 0.60. Similar findings were reported by Chehri A *et al.*[21] among a cohort of 600 individuals, with 53.3% (325) demonstrating a mediocre level of sleep hygiene (total ASHS score between 3.8 to 4.9), while 26.2% (160) displaying a poor sleep hygiene score (ASHS score <3.8) in adherence to sleep hygiene practices. Murugesan G *et al.*[8] too reported that among 538 school-aged teenagers between 10–17 years, 64% (345) had at least one kind of poor sleep hygiene behavior, and watching TV in bed was the most prominent one. A comprehensive review of studies reveals that various domains of sleep hygiene are closely associated with sleep quality.[26] Studies have demonstrated a correlation between poorer sleep hygiene practices and experiencing sleep-related issues, suggesting that the closer one adheres to sleep hygiene guidelines, the fewer sleep problems are encountered and better is the overall sleep quality.[27,28] Sleep hygiene encompasses a set of habitual practices aimed at promoting and sustaining high-quality sleep at night.[29] Among all the potential behaviors that can disrupt sleep, present study shows that about 72.1% (708) adolescents engaged in thinking about tasks they need to accomplish, while preparing to sleep, and 62% (616) adolescents tend to replay events of the day in their minds when they went to bed [Table 4]. Additionally, almost 50% of adolescents had

irregular sleep on weekdays and weekends in the sleep stability factor, 25%–30% of adolescents did not have a proper sleep environment while falling asleep [Table 4]. Interestingly, use of tobacco, alcohol, or engaging in drinking after 6 p.m. in the evening is an infrequent occurrence among Indian adolescents, as over 90% have never indulged in such activities [Table 4]. A clear relationship has been observed between sleep hygiene practices and sleep quality among adolescents, which is consistent with previous studies.[21,27,30]

Present study shows that 63.6% (625) of adolescents engaged in activities like playing video games, watching TV, or talking on telephone, an hour before bedtime. Moreover, 59.67% (586) of adolescents reported engaging in these activities, while in bed; in addition to reading and doing homework. Such behavioural arousal factors are responsible for making them feel very active an hour preceding bedtime and are observed to be associated with a decline in sleep quality [Table 5].[8] Murugesan *et al.*[8] reported that 48% (257) of adolescents had heavy meal before bed, and 76% (409) had a gap of less than one hour between dinner and bedtime. 64.1% (345) of adolescents watched TV in bed and 23.2% (125) used their mobile phones in bed.[8] Association between impaired sleep quality and watching television, particularly late at night and in bedroom, has been reported in several studies.[31,32] Letchuman *et al.*[5] also reported that adolescents, who watched TV late at night experienced excessive daytime sleepiness, indicating poor sleep quality. Use of electronic media and mobile phones has been suggested to impair sleep quality in several research studies.[33,34]

The status of sleep hygiene practices among adolescents is of growing concern and requires attention. While numerous factors contribute to poor sleep hygiene among adolescents, such as academic pressures and electronic device use, it is crucial to understand that good sleep hygiene practices are essential for adolescent's physical/mental health, and overall well-being.[35] Prevalent unhealthy sleep habits which include irregular sleep-wake schedule on weekdays and weekends, using bedrooms for watching TV, telephone, video games lead to poor sleep hygiene as per the behavioral arousal factor of ASHS and can very well be alleviated through awareness and education of sleep hygiene practices. Sleep hygiene education can be incorporated in school curriculum just as physical education to instill the discipline needed for practicing healthy sleep habits, ultimately enhancing mental and physical health.

In this study, the socioeconomic status of the family and pubertal stage of adolescents were not explored, which could have added to assessing the major hurdles for sleep hygiene practices pertaining to these factors. However, it enrolled many adolescents of varied grades from 6$^{th}$ till 12$^{th}$ from different schools and gave insight on the prevalent sleep hygiene practices, status of sleep quality and its impact on mood of Indian Adolescents. The study very well explored the significant differences in mood and sleep quality of good sleep hygiene followers (good sleepers), which would act as evidence for planning future studies and incorporating sleep education programs for adolescents. Our study has highlighted the important modifiable behaviors prevalent among adolescents which could be corrected on an individual basis for better sleep quality and mood apart from school timings which vary from school to school and need amendments at various external factors.

## Conclusion

The study highlights the importance of sleep hygiene in promoting optimal sleep quality and emotional well-being among adolescents. Despite the growing awareness of the importance of sleep hygiene, studies have shown that a significant number of adolescents still struggle with poor sleep habits, such as irregular sleep schedules and excessive screen time before bedtime. It is crucial for parents, educators, and primary healthcare physicians to work together to educate adolescents about the importance of healthy sleep habits. Investing in adolescent sleep health would not only improve their sleep quality but will also upgrade their mood enhancing their mental and psychological well-being.

### Compliance with ethical standards

Ethics approval: Approval was obtained from the Institutional Human ethics committee of AIIMS Bhopal, Madhya Pradesh, India. All procedures performed in studies involving human participants were in accordance with the Declaration of Helsinki.

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### Conflicts of interest

There are no conflicts of interest.

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# Electronic media use and sleep in children and adolescents in western countries: a systematic review

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## Abstract

**Background:** Sleep is essential for child and adolescent health and well-being. There is an increasing interest in whether electronic media use affects children and young adolescents' sleep. Prior reviews have focused on a school-aged population. Moreover, it is crucial that research continuously addresses the processes of technology and media use and the implication on sleep. This systematic review examines the evidence of electronic media use related to sleep among 0–15-year-olds.

**Methods:** Searches were carried out in four databases (CINAHL, Web of Science, EMBASE, and Medline). Inclusion criteria included age ≤ 15 years, and intervention, cohort, or cross-sectional studies from western countries. Methodological quality was rated using the Quality Assessment Tool for Quantitative Studies by two independent reviewers. Data was extracted using a standardized data extraction form. Synthesis was done by summarizing results across studies by age groups of 0–5, 6–12, and 13–15 years within four sleep domains: Bedtime and sleep onset; Sleep quality; Sleep duration; Daytime tiredness.

**Results:** The search identified 10,719 unique studies, of which 109 fulfilled inclusion and exclusion criteria and were assessed for methodological quality. In total, 49 studies were included in the review. The study designs were randomized controlled trials ($n = 3$), quasi-experimental studies ($n = 2$), prospective cohort studies ($n = 15$), and cross-sectional studies ($n = 29$). Evidence for an association between electronic media use and sleep duration was identified, with stronger evidence for 6–15-years-olds than 0–5-year-olds. The evidence for a relationship between electronic media use and other sleep outcomes was more inconclusive. However, for 6–12-year-old children, there was evidence for associations of electronic media use with delayed bedtime and poor sleep quality. For 13–15-year-olds, there was evidence for associations between screen time and problems falling asleep, and between social media use and poor sleep quality.

**Conclusions:** Overall, electronic media use was generally associated with shorter sleep duration in children and adolescents. Studies with stronger research design and of higher quality are needed to draw solid conclusions about electronic media's impact on other sleep outcomes. Public awareness and interventions could be promoted about the potential negative impact on children's sleep of electronic media devices that are used excessively and close to bedtime.

**Keywords:** Systematic review, Child, Adolescent, Telecommunications, Sleep

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## Background

Sleep has a major impact on the health and well-being of children and adolescents. Sleep is vital for development and learning ability, and insufficient sleep over an extended period can have long-term physical and psychological health implications [1]. Physiological and psychological changes that emerge in childhood and youth may impact negatively on sleep, but poor sleep is arguably also related to, or compounded by, external factors such as early school start times, environmental conditions in the bedroom (e.g. noise, high temperature or too much light) and the availability of electronic media [1–3]. *Over the last few decades, a major lifestyle change has happened due to the incorporation of electronic media device use into people's daily life. Electronic media has become a core part of young people's lives and children today are growing up surrounded by electronic media devices.* Studies demonstrate that most children, even as young as four months of age, have experience with using electronic media devices, although electronic media consumption is largest among older teenagers [4]. M*edia devices have become an integral part of children's development environment and a prevalent mode of communication among adolescents* [5]. *Although electronic media is widely accepted and accessible in the home environment, there is yet only a limited understanding of how access to and use of electronic media may impact the sleep patterns of children and adolescents.*

Technology is continuously evolving, and the way electronic media devices are used in everyday life may change over time. Although previous systematic reviews and meta-analyses have established a correlation between media use and sleep [6–8], it is crucial that research continuously addresses the processes of technology and media use and its implication on children and adolescents' sleep patterns. Therefore, reviews that include the newest types of electronic media devices and technological trends are needed. Moreover, previous reviews on this subject focus mainly on an older paediatric target group, and there is limited knowledge about the evidence of electronic media devices and the impact on sleep among pre-schoolers [9].

The aim of this study was to systematically review the literature on the impact of using electronic media on sleep in children and adolescents. The population was preschool children, school-age children up to 12-years-old and young adolescents up to 15 years old. The exposure was access to and use of electronic media devices, and the outcomes were bedtime and sleep onset, sleep quality during nighttime, sleep duration and daytime tiredness. The intention was to inform policy and practice and to highlight what further research is needed on this topic.

## Methods

*A narrative method was applied to synthesis the data on the association between electronic media use and sleep among children and adolescents.*

### Eligibility criteria

We included studies which fulfilled the following eligibility criteria: (1) Assessed the associations between the use of or access to electronic media devices and sleep, i.e. delayed bedtime, sleep onset latency, sleep quality during night-time, sleep duration and daytime tiredness; (2) Published in English between January 1, 2009 and August 31, 2019; (3) From western countries; (4) Examined children and adolescents between 0 and 15.9 years of age without any diagnoses/diseases. Electronic media devices were defined as mobile phones, televisions, touchscreens/tablets, computers, or video game consoles. The exclusion criteria were apps intended to treat sleep disorders, or problems (e.g., sleep apnoea), and studies examining electromagnetic radiation.

### Data sources and search strategy

The PICo model was used to generate the search strategy, and the search strategy was divided into three search blocks: P (Patient / Problem / Population), I (Phenomenon of interest), and Co (Context). The population was children and adolescents aged 0–15; the field of interest was electronic media devices, and the context was before sleep (bedtime and sleep onset), during sleep (sleep quality during nighttime), and after sleep (sleep duration and daytime tiredness). We performed a systematic search in four databases: CINAHL, EMBASE, Web of Science, and Medline based on keywords (subject headings/MeSH terms) and free text searches (title, keywords, text). The search terms and syntax included relevant synonyms for the search terms adolescents/children (e.g. minor, teenager), electronic media devices (e.g. cell phone, screen), and sleep (e.g. sleep latency, bedtime routine) (see Supplementary eTable 1 for the full search in each database). In addition, we included previous reviews to identify relevant studies.

### Study selection; screening, quality assessment, and data extraction

Title and abstracts identified were screened for eligibility, and full texts of potentially eligible articles were read and assessed by two reviewers (LL and INS) independently. Discordance regarding inclusion was resolved through discussion. Two reviewers (LL and SA) independently assessed the methodological quality of the included quantitative studies. To ensure consistency in the quality assessments, meetings were held on an ongoing basis, focusing on inter-rater reliability. The methodological quality of the quantitative articles was assessed using the Effective Public Health Practice Project (EPHP P) assessment tool [10], based on the following five components: selection bias, study design, confounders, data collection methods, and withdrawal/dropouts. The EPHPP covers any quantitative study design, it is

developed for use within public health and has been found to have psychometric properties as good as the Cochrane risk-of-bias tool. Each study was rated as high, moderate, or low quality. Low-quality studies were excluded to ensure moderate evidence. We extracted the data using a standardized data extraction form. It included country of study, age, sex, study design, sleep outcomes, exposure (electronic media device measures) and reported associations. Synthesis was done by summarizing results and conclusions across studies grouped by age groups of 0–5.9 years, 6–12.9 years, and 13–15.9 years within four sleep domains: Bedtime and sleep onset; Sleep quality; Sleep duration; Daytime tiredness. If a study included data on ages overlapping the defined age categories, we used the mean age to allocate the study to an age category. A few studies ($n = 2$) included a large age span. However, these studies had performed analyses by subgroups of age corresponding to our categories.

## Results

A total of 446 full texts were reviewed, of which 338 were excluded (Fig. 1). We identified 7 qualitative studies of which 3 studies received high- or moderate-quality assessments. These studies focused on factors (e.g. the role of parents) that facilitate the accessibility and acceptability of electronic media use in relation to sleep, and not on how electronic media use might impact sleep in children and adolescents. The results from the qualitative studies will be reported in a separate paper given the focus on quantitative studies in this systematic review.. In total, 52 quantitative studies were not included because they received a low-quality assessment rating as a result of a range of methodological issues: weakness in study design, a small percentage of responses, not controlling for confounders, and not reporting validity and reliability of measures used. Of the 49 included quantitative studies, four studies received a high-quality assessment rating, and 45 studies received a moderate-quality assessment rating. Of the included studies, 18 were conducted in North America (USA and Canada) [11–28], 23 in Europe (England, Finland, Sweden, Holland, Switzerland, France, Italy, Spain, and Germany) [29–51], five in Australia and New Zealand [52–56], and three studies combined several western countries [57–59]. There were three randomized controlled trials (RCTs) [27, 28, 50], two quasi-experimental studies [26, 51], 15 prospective cohort studies [12, 16, 19, 24, 30, 32, 35, 37, 40, 42, 45, 47, 48, 52, 55], and 29 cross-sectional studies [11, 13–15, 17, 18, 20–23, 25, 29, 31, 33, 34, 36, 38, 39, 41, 43, 44, 46, 49, 53, 54, 56–59] (see Table 1 for chacteristics of the included studies). *The majority of the included studies adjusted for all or most of the following confounders: ethnicity, age/grade, sex, and socioeconomic status (*e.g.*, parental education and/or parental occupation). Some studies also included health factors such as BMI, psychological symptoms, and physical activities.* Detailed descriptions of study design and results are available in Supplementary eTables 2–4, and references on excluded studies in Supplementary eTable 5.

### Electronic media use among children aged 0–5

Table 2 summarizes the results of the 13 studies [11–15, 27, 29–32, 52, 56, 57] included for 0–5-year-olds.

#### *Bedtime and sleep onset*

Five studies analysed the association between electronic media use and late bedtime and/or sleep onset [11, 13, 14, 29, 52]. Three studies examined tablet use and found an association of tablet use (both general and at bedtime) with delayed bedtime or sleep onset latency [11, 13, 14]. There were two studies on television viewing before bedtime and both found an association with delayed bedtime or sleep onset latency [11, 13]. Two studies estimated the association between mobile phone use and delayed bedtime or sleep onset latency with one finding a positive association for the use of mobile phones at night-time [14] and one finding no association [11]. The association between gaming and delayed bedtime or sleep onset latency was examined in three studies [11, 13, 14] with one study reporting an association [13]. One longitudinal study examined screen time in 2-year-olds and found a positive association with sleep onset latency in 5-year-olds [52]. No evidence was found for an association between computer/Internet use and delayed bedtime/sleep onset [11, 13, 14]. One study found an association between the presence of a television in the bedroom and delayed bedtimes on weekdays, but not on weekends [13].

#### *Sleep quality*

There was no evidence for television viewing or use of touchscreens [29], while there was inconsistent evidence for general screen time use [15, 52, 56] on night awakenings or sleep disturbances. An intervention study showed that promotion of prosocial content on electronic media reduced sleep problems [27].

#### *Sleep duration*

Regarding sleep duration, three studies showed that overall screen time was associated with shorter sleep duration [15, 52, 57], and six studies showed this concerning television viewing [11–13, 30–32] and three studies concerning use of touch screen or tablet [11, 14, 29]. Lack of association was found for the use of mobile phones [11, 14], video gaming [11, 13, 14] and computers or Internet [11, 13, 14]. Inconsistent evidence was found for the presence of electronic media devices in the bedroom [12, 13]; for ethnic minority children, television

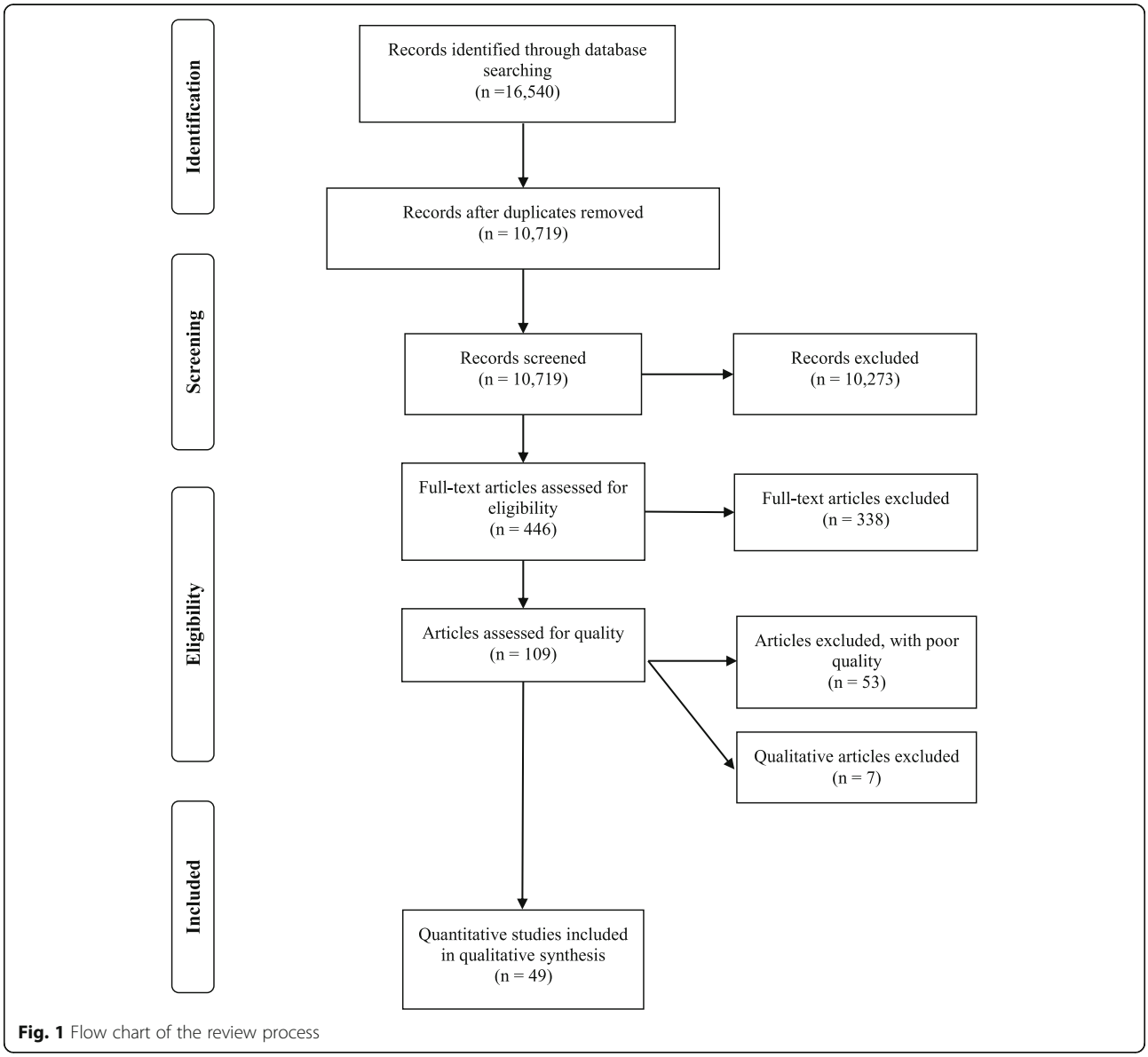


**Fig. 1** Flow chart of the review process

in the bedroom among 4-year-olds was associated with 32 fewer minutes of sleep per day at age 7 [12].

### *Daytime sleep duration*

Three studies found associations between television viewing and longer naps [11, 13, 29], while inconsistent evidence was found for the use of mobile phones [11, 14] and touch screen or tablet [11, 14, 29]. No evidence was found for gaming, computer or internet use, and the presence of electronic media devices in the bedroom [11, 13, 14].

## Electronic media use among children aged 6–12

Table 3 summarizes the results for the 15 studies [15–21, 28, 30, 33–37, 53] included for the age range 6–12.

### *Bedtime and sleep onset*

Six studies analysed the association between electronic media use and late bedtime and/or sleep onset [18, 33, 35–37, 53]. Five of the studies found an association. Some studies only found an association when stratified by specific variables such as weekends/weekdays. For example, Mireku et al. (2019) showed that use of screen-based media device in the last hour before bedtime was associated with 1.44 times the odds of delayed sleep onset on weekends, but no association was found on weekdays [36]. Two studies assessed the association between video gaming and sleep onset [18, 33]. Arora et al. (2014) showed that high frequency of gaming at bedtime was associated with a 6.2 min prolonged sleep onset on weekdays [33]. Falbe et al. (2015) reported that each hour per day of gaming was associated with a 9.8 min

**Table 1** Study characteristics of the 49 included studies in the systematic review

| | n (%) |
|---|---|
| **Geographic location** | |
| North America | 18 (37) |
| Europe | 23 (47) |
| Australia and New Zealand | 5 (10) |
| Several western countries included | 3 (6) |
| **Age range** | |
| 0–5 years | 11 (22) |
| 6–12 years | 13 (27) |
| 13–15 years | 23 (47) |
| 0–15 years[a] | 2 (4) |
| **Study design** | |
| RCT study | 3 (6) |
| Quasi-experimental study | 2 (4) |
| Prospective cohort study | 15 (31) |
| Cross-sectional study | 29 (59) |
| **Electronic media devices**[b] | |
| Television | 18 (37) |
| Video game | 12 (25) |
| Mobile phone/smartphone | 13 (27) |
| Computer/internet | 14 (29) |
| Touchscreen/tablet | 3 (6) |
| Social media | 7 (14) |
| Total screen time | 43 (21) |
| Electronic media devices in the bedroom | 5 (10) |
| Media content (e.g., violent content) | 1 (2) |
| **Sleep outcome**[c] | |
| Delayed bedtime/sleep onset latency | 22 (45) |
| Poor sleep quality | 19 (29) |
| Short sleep duration | 36 (73) |
| Daytime tiredness | 15 (31) |

[a]We have predefined three age group categories. If a study included data on ages overlapping the defined age categories, we used the mean age to allocate the study to an age category. A few studies (n = 2) included a large age span

[b]As some articles examine several electronic media devices within the same study, this column does not add up to 100%

[c]As some articles examine several sleep outcomes within the same study, this column does not add up to 100%

later bedtime [18]. Two studies found that electronic media in the bedroom, including mobile phones, televisions, and computers, were associated with later bedtimes [18, 37]. One of the studies, however, only found a significant association among boys, not girls [37]. One study did not find that electronic media devices in the bedroom was associated with sleep latency and trouble falling asleep [33].

#### *Sleep quality*

Six of eight studies found a positive association between the use of electronic media, including total screen time and bedtime use of television and mobile phone, and night-time awakenings/sleep disturbances [15, 33, 35, 53] or poor sleep quality [20, 36]. For example, Mireku et al. (2019) found that using mobile phone or watching television in the dark was associated with restless sleep, waking up at night, and waking early in the morning [36].

#### *Sleep duration*

A total of 15 studies were identified, examining the association between electronic media use and sleep duration among 6–12-year-olds [15–21, 28, 30, 33–37, 53]. The studies found use of mobile phone [17, 33, 35, 36], social media [33], and computer or television [17, 18, 21, 30, 33, 36, 37] associated with short sleep duration. Six studies examined the association between electronic media in the bedroom and sleep duration [17, 18, 28, 33, 34, 37]. Among these studies, three found an association. Chahal et al. (2012) showed a dose-response association, where children who had access to more electronic media in their bedroom slept less [17]. Falbe et al. (2015) found that children who slept close to a small screen (e.g., mobile phone) reported 21 min less sleep compared to children who did not [18].

#### *Daytime tiredness*

Two studies examined mobile phone use and daytime tiredness [35, 53]. Redmayne et al. (2013) found that children disturbed by their mobile phone at night at least once a week were 3.5 times more likely to experience daytime tiredness than children who were not disturbed by their mobile phone at night [53]. Huss et al. (2015) did not find an association [35].

### Electronic media use among children aged 13–15

Table 4 summarizes the results of the 24 studies [15, 22–26, 38–51, 54, 55, 58, 59] included in the age range 13–15.

#### *Bedtime and sleep onset*

Eleven studies investigated the relationship between electronic media use and delayed bedtime and sleep onset [23, 24, 40, 43, 45, 46, 48–51, 59]. Nine of these studies showed a positive association [23, 40, 43, 45, 46, 48, 49, 51, 59]. High electronic media use was associated with problems falling asleep/later sleep onset [23, 40, 45, 46, 51, 59], delayed bedtime [43, 46, 49] and bedtime problems [45] The study by Poulain et al. (2019) showed a positive association for high use of computer or Internet (3–4 h/day or more) and more bedtime problems at 12-month follow-up, while no association was found for television viewing or mobile phone use [45]. Two studies

**Table 2** Summary of studies and their findings on the relationship between electronic media devices and sleep outcomes among 0–5-year-olds

| Electronic media device | Measured at bedtime | Sleep outcomes | | | | Study design | Quality Assessment |
|---|---|---|---|---|---|---|---|
| | | Delayed bedtime or sleep onset latency | Poor sleep quality | Short sleep duration | Daytime sleep duration/ Daytime tiredness | | |
| **Television** | | | | | | | |
| Beyens 2019 | No | + | | +/0 | + | Cross-sectional | Moderate |
| | Yes | + | | +/0 | 0 | | |
| Cespedes 2014 | No | | | + | | Cohort study | Moderate |
| Cheung 2017 | No | 0 | 0 | 0 | + | Cross-sectional | Moderate |
| Marinelli 2014 | No | | | + | | Cohort study | Moderate |
| McDonald 2014 | Yes | | | + | | Cross-sectional | Moderate |
| Moorman 2019 | No | 0 | | + | + | Cross-sectional | Moderate |
| | Yes | + | | + | 0 | | |
| Plancoulaine 2018 | No | | | + | | Cohort study | Moderate |
| **Video game (console)** | | | | | | | |
| Beyens 2019 | No | 0 | | 0 | 0 | Cross-sectional | Moderate |
| | Yes | 0 | | 0 | 0 | | |
| Moorman 2019 | No | + | | 0 | 0 | Cross-sectional | Moderate |
| | Yes | + | | 0 | | | |
| Nathanson 2018 | No | 0 | | 0 | 0 | Cross-sectional | Moderate |
| | Yes | 0 | | 0 | 0 | | |
| **Mobile phone** | | | | | | | |
| Beyens 2019 | No | 0 | | 0 | +/0 | Cross-sectional | Moderate |
| | Yes | 0 | | 0 | + | | |
| Nathanson 2018 | No | 0 | | 0 | 0 | Cross-sectional | Moderate |
| | Yes | + | | 0 | 0 | | |
| **Touchscreen/tablet** | | | | | | | |
| Beyens 2019 | No | + | | +/0 | + | Cross-sectional | Moderate |
| | Yes | + | | +/0 | +/0 | | |
| Cheung 2017 | No | + | 0 | + | 0 | Cross-sectional | Moderate |
| Nathanson 2018 | No | + | | + | 0 | Cross-sectional | Moderate |
| | Yes | + | | + | 0 | | |
| **Computer/internet** | | | | | | | |
| Beyens 2019 | No | 0 | | 0 | 0 | Cross-sectional | Moderate |
| | Yes | 0 | | 0 | 0 | | |
| Moorman 2019 | No | 0 | | +/0 | 0 | Cross-sectional | Moderate |
| | Yes | 0 | | 0 | 0 | | |
| Nathanson 2018 | No | 0 | | 0 | 0 | Cross-sectional | Moderate |
| | Yes | 0 | | 0 | 0 | | |
| **Total screen time** | | | | | | | |
| Parent 2016 | No | | + | + | | Cross-sectional | Moderate |
| Ribner 2019 | No | | | + | 0 | Cross-sectional | Moderate |
| Xu 2016 | No | + | − | + | | Cohort study | Moderate |
| Zhang 2018 | No | | 0 | 0 | | Cross-sectional | Moderate |

**Table 2** Summary of studies and their findings on the relationship between electronic media devices and sleep outcomes among 0–5-year-olds *(Continued)*

| Electronic media device | Measured at bedtime | Sleep outcomes | | | | Study design | Quality Assessment |
|---|---|---|---|---|---|---|---|
| | | Delayed bedtime or sleep onset latency | Poor sleep quality | Short sleep duration | Daytime sleep duration/ Daytime tiredness | | |
| **Electronic media devices in the bedroom** | | | | | | | |
| Cespedes 2014 | | | | +/0 | | Cohort study | Moderate |
| Moorman 2019 | | + | | 0 | 0 | Cross-sectional | Moderate |
| **Media content** | | | | | | | |
| Garrison 2012 | No | | + | | | RCT | Moderate |

Note: 1st author and year. (+) Significant positive association; (0) No association; (−) Significant negative association; (+/0) refers to both a positive association and no association in different subgroups

found an association between social media use and delayed sleep onset [46, 48]. Van der Schuur et al. (2019) found that social media stress was longitudinally related to sleep onset latency among girls, but not boys [48]. Scott et al. (2019) found a dose-response relationship between social media use and late sleep onset, where a higher use of social media was associated with higher odds of late sleep onset [46].

### *Sleep quality*

Nine studies assessed the association between electronic media use and sleep quality, including restless sleep, night-time awakenings, and insomnia complaints [15, 40, 41, 44–46, 50, 54, 55] and seven of these studies found a positive association [15, 40, 41, 44, 46, 54, 55]. Three of these studies examined social media use [46, 54, 55]. There were indications that a large amount of time on social media or problematic use of social media had an impact on sleep quality [46, 54, 55]. Problematic use of social media was measured by whether the adolescents preferred spending time on social media rather than engaging in social activities or used social media to feel good about themselves.

### *Sleep duration*

The relationship between electronic media use and sleep duration was examined in 13 studies [15, 22–26, 38, 39, 42, 50, 51, 58, 59]. Mazzer et al. (2018), who examined eighth- and ninth-grade students over a year, found that of electronic media use was associated with short sleep duration [42]. Regarding different types of electronic media, it appears that computers [22, 24, 38, 58], mobile phones [22, 24, 38], and video games [22, 38] affected sleep duration. Brunetti et al. (2016), for example, found that computer use doubled the odds of a short night's sleep, while talking on a mobile phone tripled the odds of a short night's sleep [22]. In contrast, Tavernier et al. (2017) found that talking on the phone increased the sleep duration, whereas texting reduced the sleep duration. In this study, social media use was not related to sleep duration, whereas Twenge et al. (2017) found an association between social media and short sleep duration. Two studies investigated the presence of electronic media in the bedroom and sleep duration. There were indications that a computer, but not a television or gaming console, in the bedroom negatively affected sleep duration [23, 39].

### *Daytime tiredness*

Eight studies examined the association between electronic media use and daytime tiredness, and found mixed results [22, 23, 40, 45, 47–50]. Poulain et al. (2019) showed that high computer or Internet use, but not television and mobile phone use, resulted in more daytime tiredness [45]. Brunetti et al. (2016) found that computer use and time spent talking on the mobile phone were associated with more daytime sleepiness while no associations were found for videogame time and television use [22]. One study that examined social media showed that using social media was not in itself associated with daytime tiredness, but adverse emotional reactions arising from social media (i.e. social media stress) was related to daytime tiredness among girls [48].

## Discussion

This systematic review summarizes results from 49 epidemiological studies on associations between electronic media use and sleep in 0–15-year-old children and adolescents. Across age groups, we found consistent evidence that media use was associated with short sleep duration. The evidence for a relationship between electronic media use and other sleep outcomes was less strong.

For the youngest children (i.e. preschool children), television watching, and tablet device use were associated with difficulties in falling asleep and less sleep duration. Moreover, heavier television use was associated with increased daytime napping, which suggests poorer

**Table 3** Summary of studies and their findings on the relationship between electronic media devices and sleep outcomes among 6–12-year-olds

| Electronic media device | Measured at bedtime | Sleep outcomes | | | | Study design | Quality Assessment |
|---|---|---|---|---|---|---|---|
| | | Delayed bedtime or sleep onset latency | Poor sleep quality | Short sleep duration | Daytime tiredness | | |
| **Television** | | | | | | | |
| Arora 2014 | Yes | 0 | + | + | | Cross-sectional | Moderate |
| Chahal 2012 | Yes | | | + | | Cohort study | Moderate |
| Falbe 2014 | No | + | | + | | Cross-sectional | Moderate |
| Marinelli 2014 | No | | | + | | Cohort study | Moderate |
| Mireku 2019 | Yes | + | + | + | | Cross-sectional | Moderate |
| Nuutinen 2013 | No | + | | + | | Cohort study | Moderate |
| Yland 2015 | No | | | + | | Cross-sectional | Moderate |
| **Video game (console)** | | | | | | | |
| Arora 2014 | Yes | + | + | + | | Cross-sectional | Moderate |
| Chahal 2012 | Yes | | | + | | Cohort study | Moderate |
| Falbe 2014 | No | + | | + | | Cross-sectional | Moderate |
| Yland 2015 | No | | | 0 | | Cross-sectional | Moderate |
| **Mobile phone** | | | | | | | |
| Arora 2014 | Yes | +/0 | + | + | | Cross-sectional | Moderate |
| Chahal 2012 | Yes | | | + | | Cohort study | Moderate |
| Huss 2015 | No | + | + | + | 0 | Cohort study | Moderate |
| Mireku 2019 | Yes | + | + | + | | Cross-sectional | Moderate |
| Redmayne 2013 | No | 0 | 0 | 0 | + | Cross-sectional | Moderate |
| **Computer** | | | | | | | |
| Arora 2014 | Yes | +/0 | + | + | | Cross-sectional | Moderate |
| Chahal 2012 | Yes | | | + | | Cohort study | Moderate |
| Nuutinen 2013 | No | + | | + | | Cohort study | Moderate |
| Yland 2015 | No | | | +/0 | | Cross-sectional | Moderate |
| **Internet/social media** | | | | | | | |
| Arora 2014 | Yes | + | 0 | + | | Cross-sectional | Moderate |
| **Total screen time** | | | | | | | |
| Barlett 2011 | No | | | + | | Cohort study | Moderate |
| Brambilla 2017 | Yes | | | + | | Cross-sectional | Moderate |
| Gentile 2014 | No | | | + | | Cohort study | Moderate |
| Greever 2017 | No | | + | 0 | | Cross-sectional | Moderate |
| Mireku 2019 | Yes | + | | + | | Cross-sectional | Moderate |
| Parent 2016 | No | | + | + | | Cross-sectional | Moderate |
| **Electronic media devices in the bedroom** | | | | | | | |
| Arora 2014 | | 0 | 0 | + | | Cross-sectional | Moderate |
| Brambilla 2017 | | | | 0 | | Cross-sectional | Moderate |
| Chahal 2012 | | | | + | | Cohort study | Moderate |
| Falbe 2014 | | + | | + | | Cross-sectional | Moderate |
| Mindell 2016 | | | | 0 | | RCT | Moderate |
| Nuutinen 2013 | | + | | +/0 | | Cohort study | Moderate |

Note: 1st author and year. (+) Significant positive association; (0) No association; (+/0) refers to a positive association and no association for different outcome measures

**Table 4** Summary of studies and their findings on the relationship between electronic media devices and sleep outcomes among 13–15-year-olds

| Electronic media device | Measured at bedtime | Sleep outcomes | | | | Study design | Quality Assessment |
|---|---|---|---|---|---|---|---|
| | | Delayed bedtime or sleep onset latency | Poor sleep quality | Short sleep duration | Daytime tiredness | | |
| **Television** | | | | | | | |
| Arora 2013 | Yes | | | + | | Cross-sectional | Moderate |
| Brunetti 2016 | No | | | – | 0 | Cross-sectional | Moderate |
| Lange 2015 | No | | 0 | | | Cross-sectional | Moderate |
| Poulain 2019 | No | 0 | 0 | | 0 | Cohort study | High |
| Tavenier 2017 | No | 0 | | 0 | | Cohort study | High |
| Twenge 2017 | No | | | +/0 | | Cross-sectional | Moderate |
| **Video game (console)** | | | | | | | |
| Arora 2013 | Yes | | | + | | Cross-sectional | Moderate |
| Brunetti 2016 | No | | | +/0 | 0 | Cross-sectional | Moderate |
| Lange 2015 | No | | +/0 | | | Cross-sectional | Moderate |
| Tavernier 2017 | No | 0 | | 0 | | Cohort study | High |
| Wallenius 2009 | No | +/– | | | + | Cross-sectional | Moderate |
| **Mobile phone/smartphone** | | | | | | | |
| Arora 2013 | Yes | | | + | | Cross-sectional | Moderate |
| Brunetti 2016 | No | | | + | + | Cross-sectional | Moderate |
| Foerster 2019 | No | + | +/0 | | 0 | Cohort study | Moderate |
| Lange 2015 | No | | 0 | | | Cross-sectional | Moderate |
| Poulain 2019 | No | 0 | 0 | | 0 | Cohort study | High |
| Tavernier 2017 | No | 0 | | + | | Cohort study | High |
| **Computer/internet** | | | | | | | |
| Arora 2013 | Yes | | | + | | Cross-sectional | Moderate |
| Brunetti 2016 | No | | | + | + | Cross-sectional | Moderate |
| Lange 2015 | No | | +/0 | | | Cross-sectional | Moderate |
| Nuutinen 2014 | No | | | + | | Cross-sectional | Moderate |
| Poulain 2019 | No | + | 0 | | + | Cohort study | High |
| Tavernier 2017 | No | 0 | | + | | Cohort study | High |
| Twenge 2017 | No | | | + | | Cross-sectional | Moderate |
| **Social media** | | | | | | | |
| Scott 2019 | No | + | + | | | Cross-sectional | Moderate |
| Tavernier 2017 | No | 0 | | 0 | | Cohort study | High |
| Twenge 2017 | No | | | + | | Cross-sectional | Moderate |
| Van der Schuur 2019 | No | + | | | +/0 | Cohort study | Moderate |
| Vernon 2015 | No | | + | | | Cross-sectional | Moderate |
| Vernon 2017 | No | | + | | | Cohort study | Moderate |
| **Total screen time** | | | | | | | |
| Bickham 2018 | No | | | + | | Quasi-experimental | High |
| Calamaro 2009 | Yes | + | | + | + | Cross-sectional | Moderate |
| Das_Friebel 2018 | Yes | 0 | 0 | 0 | 0 | RCT | High |
| Foerster 2019 | No | + | 0 | | + | Cohort study | Moderate |

**Table 4** Summary of studies and their findings on the relationship between electronic media devices and sleep outcomes among 13–15-year-olds *(Continued)*

| Electronic media device | Measured at bedtime | Sleep outcomes | | | | Study design | Quality Assessment |
|---|---|---|---|---|---|---|---|
| | | Delayed bedtime or sleep onset latency | Poor sleep quality | Short sleep duration | Daytime tiredness | | |
| Lange 2015 | No | | +/0 | | | Cross-sectional | Moderate |
| Mazzer 2018 | No | | | + | | Cohort study | Moderate |
| Ogunleye 2015 | No | + | | | | Cross-sectional | Moderate |
| Ononogbu 2014 | No | | + | | | Cross-sectional | Moderate |
| Parent 2016 | No | | + | 0 | | Cross-sectional | Moderate |
| Perrault 2019 | Yes | + | | + | | Quasi-experimental | Moderate |
| Twenge 2017 | No | | | + | | Cross-sectional | Moderate |
| Van der Schuur 2018 | No | | 0 | | 0 | Cohort study | Moderate |
| Vandendriessche 2019 | No | + | | + | | Cross-sectional | Moderate |
| **Electronic media devices in the bedroom** | | | | | | | |
| Calamaro 2009 | | | | 0 | | Cross-sectional | Moderate |
| Continente 2016 | | | | +/0 | | Cross-sectional | Moderate |

Note: 1st author and year. (+) Significant positive association; (0) No association; (–) Significant negative association; (+/0) refers to both a positive association and no association in different subgroups; (+/–) refers to both a positive association and a negative association in different subgroups

sleep consolidation and less mature sleep patterns [60]. There was no or insufficient evidence for an association of video game, mobile phone, computer, and the presence of an electronic media device in the bedroom with poor sleep outcomes among 0–5-year-olds.

For 6–12-year-old children, use of electronic media (television, video game console, mobile phone, computer, screen time) in general and at bedtime and their presence in the bedroom was associated with later bedtimes and shorter sleep duration. Additionally, we found evidence for an association of bedtime television and mobile phone use as well as total screen time with sleep disturbances and awakening at night. Similar results have been reported in a previous systematic review examining the association between portable screen-based media device access or use in the bedroom and less sleep [61]. Our results support the hypothesis that evening exposure to bright light from screens may disturb the sleep-wake cycle and suppresses the melatonin production [7, 62]. Other mechanisms through which media use may interfere with sleep onset and sleep problems are time replacement (i.e. time spent on the screens at night displaces time spent sleeping) or the psychological stimulation from the media content [63].

For 13–15-year-olds, there was evidence for a positive association of total screen time and use of computer and mobile phone with less sleep. Moreover, the included studies indicated that screen time was associated with problems falling asleep, and social media use was associated with poor sleep quality. Television watching was least likely to be associated with poor sleep outcomes. Thus, for this age group our study supports that more interactive forms of electronic media with increases in physiological arousal [64] may have greater impact on sleep than more passive forms [7, 65]. Our results are in line with a systematic review [66] including an older age group (15–24-year-olds) that suggests that adolescents often use electronic devices for social media, and this may explain the relationship between use of electronic media device and poor sleep.

Five of the included studies investigated subgroup effect or effect modification, i.e. whether an observed association differed depending on characteristics of the study sample. Four studies performed gender-specific analyses [39, 40, 48, 49] and one study examined ethnicity [12]. The studies found that the association between electronic media use and sleep may depend on gender and ethnicity. For example, a study from US found that bedroom TV was associated with less sleep for ethnic minority children but not among white non-Hispanic children [12]. Future studies of properly powered subgroup analysis should further investigate whether the association between media use and sleep in children and adolescent is differentially impacted by factors such as age and ethnicity [67]. Moreover, how does parenting style, values, and socioeconomic status of the family contribute to the impact of electronic media on sleep. Improvements in sociocultural and contextual understanding would

elucidate the association between media use and sleep in childhood and adolescence [68].

### Limitations and future directions

We noted several limitations in the studies included in this review. Firstly, most of the study designs were cross-sectional which precluded causal inferences and limit the conclusions of this review because it is not possible to uncover the direction of relationships between electronic media and sleep. Some children and adolescents may experience bedtime procrastination (i.e. going to bed later than intended despite the absence of external reasons) [69] and use electronic media as an activity before sleep. Others may use electronic media to help them go to sleep [70] or because of tiredness [42]. Such reciprocal associations are confirmed by some of the included studies [42, 45]. Prospective studies with measurements at multiple time points are needed to identify how and when use of electronic media impact on sleep in childhood and youth. Secondly, both self-reported and parent-reported data may be subject to uncertainty. For example, adolescents tend to over-report their sleep duration compared with objective measurements such as actigraphy or diary methods [71], and parents tend to report better sleep for adolescents compared with both self-reported and objective measurements [72]. Thirdly, the included studies were measuring media use and sleep outcomes differently (e.g., overall screen time exposure versus bedtime use). Due to the substantial heterogeneity in measurements of media and sleep as well as in effect size measure, it was difficult to summarize the results, estimate the magnitude of the associations and provide clear conclusions. Nonetheless, we have rigorously outlined the associations between electronic media and each sleep outcome which enables comprehensive results; still, there were several insufficiencies. The studies among 6–12-year-olds lacked measurements of sleepiness during daytime; a factor that may have serious consequences on schoolwork and leisure activities. In the age group of 13–15-year-olds, there was a lack of studies measuring the electronic media use at bedtime or during the night. This is an important area to examine because parental monitoring and parent-set bedtimes decline significantly from early to late years of adolescence [73] which might imply an increase in the use of electronic media devices at bedtime.

This review was limited to include studies published in English and study populations from Western countries. The latter make us able to generalize to Western countries but limits the generalizability of our findings to non-Western countries. The reason for the inclusion criteria was that traditions, values, conditions and environments for sleep practices and attitudes may differ between Western and non-Western countries [74], inhibiting results to inform policy and practice.

Despite these limitations, we note several strengths of this study in addressing the association between electronic media device use and sleep in children and adolescents. First, the studies represented a relatively short period of time which ensured that the definition of electronic media devices remained stable. Secondly, we excluded studies of low quality. Thirdly, we included a broad age group; children and adolescents from 0 to 15. This broadens our understanding of how the use of electronic media devices may impact sleep in different age groups in a childhood development perspective. However, comprehensive equity reviews on e.g. socioeconomic background in the study population and mechanisms would provide a more thorough understanding of the associations. Only a few qualitative studies were identified. This leaves a large gap in understanding the complexities of electronic media device use and sleep relationship in children and adolescents.

### Implications for policy and practice

At the policy level, information and more public awareness could be promoted about the potential negative impact on children's sleep of electronic media, if used excessively and immediately before bedtime. In general, this could include renewed awareness and promotion of appropriate sleep hygiene, but also more attention to the potential adverse effects of the seemingly unavoidable increase in the use of electronic media in the everyday life. At the practice level, professionals and caretakers of children and adolescents should have a heightened awareness on sleep and encourage bedtime routines including calming activities without use of electronic media and remove all electronic media from the bedroom [75]. Given the strong attraction of electronic media on most children, interventions should include both structural measures to guide children's electronic media habits and individual measures focusing on e.g. information about the potential impact of electronic media devices and how to develop healthy media habits.

## Conclusions

This systematic review of 49 studies found consistent evidence that use of electronic devices is associated with shorter sleep duration in children and adolescents. The association between electronic media use and other sleep outcomes was more inconclusive. Moreover, the evidence for association between electronic media and sleep was stronger for 6–15-years-olds than 0–5-year-olds.

### Abbreviations
N: Number; RCT: Randomized controlled trial

## Supplementary Information
The online version contains supplementary material available at https://doi.org/10.1186/s12889-021-11640-9.

**Additional file 1: Table S1**: Search terms and syntax. **Table S2**: Characteristics and detailed results of included studies among 0–5-year-old children. **Table S3**: Characteristics and detailed results of included studies among 6–12-year-old children. **Table S4**: Characteristics and detailed results of included studies among 13–15-year-old children. **Table S5**: References on excluded studies.

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### Authors' contributions
Affiliation: National Institute of Public Health, University of Southern Denmark, Copenhagen, Denmark.
Contributions: LL and SA designed the study. LL and ISN conducted the database searches and extracted data. LL, ISN and SA did the initial analysis and DD supervised data analysis. LL and SA wrote the first draft, and ISN and DD critically revised the first draft. All authors have read, reviewed, and approved the final manuscript.

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### Availability of data and materials
All data generated or analyzed during this study are included in this article (and its supplementary files).

## Declarations

### Ethics approval and consent to participate
Ethics approval and consent to participate was not required for this review.

### Consent for publication
Not applicable.

### Competing interests
The authors declare no conflict of interest.

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