Research Article

Relationship Between Smartphone Usage Patterns, Sleep Quality, and Cognitive Function in Adolescents: A Systematic Review

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Abstract

Aim: To assess associations between smartphone-use patterns, sleep quality and cognitive or academic outcomes among adolescents. Methods: Seven primary publications representing eight analytic samples were synthesised narratively. Exposure timing, problematic use and checking frequency were evaluated separately; effects were not pooled because exposure definitions and endpoints differed. Results: In a Turkish survey of 1,959 students, poor sleep quality affected 53.0% and problematic smartphone-use thresholds were met by 27.5%; the corresponding sleep correlation was r = 0.291. Intensive monitoring of 71 adolescents associated night-time, but not daytime, use with delayed sleep onset. A prospective cohort included 9,398 adolescents and linked bedtime phone behaviours with subsequent sleep outcomes. Among 79 youths, mean school-hour checking frequency was 64.46 times; checking was associated with weaker inhibitory control in a smaller tested subset ($F[1,28] = 4.8$, $p = 0.04$). A separate longitudinal cohort of 7,043 related sleep and broader screen exposure to cognitive-score change. Conclusion: Timing, bedtime access and repeated checking appear more informative than undifferentiated screen duration. Evidence for sleep-mediated cognitive impairment remains insufficient.

Keywords: adolescent behaviour; cognitive control; digital media; sleep quality; smartphone use.

Summary

- Adolescents engage with smartphones in different ways, but the relative importance of use timing, checking and problematic engagement for sleep and cognition remains uncertain.
- Across seven primary publications, bedtime exposure was more consistently related to sleep disruption, while school-hour checking showed a narrower association with inhibitory control.
- Clinical assessment should distinguish overnight use from daytime activity and avoid interpreting observational associations as proof of cognitive injury.

Introduction

Adolescence is a developmental interval in which circadian timing shifts towards later sleep onset while academic responsibilities, peer interaction and independent device access increase. Smartphones may facilitate learning and communication, but constant availability introduces competing opportunities for night-time interaction and frequent interruptions during school activities. Exposure should be defined by timing, purpose and pattern rather than the simple number of hours spent looking at a screen. Earlier systematic reviews have associated screen-based media with delayed bedtime and reduced sleep duration, while emphasising confounding and heterogeneous measurement [1–3].

Sleep quality is not equivalent to sleep duration. It includes sleep initiation, awakenings, efficiency, perceived restoration and next-day function. The Pittsburgh Sleep Quality Index (PSQI) measures subjective aspects of sleep and may capture distress not reflected by actigraphy. Smartphone-related exposures likewise range from voluntary evening communication and passive notifications to active pickups, repetitive checking and loss of control over use. These distinctions may be important for selecting prevention strategies [4–6].

Cognitive function includes sustained attention, inhibitory control, working memory, episodic memory and executive planning. Educational marks, school engagement and procrastination are valuable functional measures but cannot be substituted for standardised cognitive tests. The relations between phone use, sleep

and cognition could be bidirectional: inadequate sleep may increase distracted use, while anxiety, academic pressure and family routines may influence both. Experimental work on light-emitting devices offers a plausible circadian mechanism, but it does not directly establish a smartphone-related cognitive deficit in adolescents [7,8].

This review examines three linked questions: whether bedtime exposure and problematic use relate to adolescent sleep quality; whether repeated smartphone checking relates to objectively measured cognitive control; and whether longitudinal sleep and screen-use patterns correspond to subsequent academic or cognitive change. The review distinguishes evidence drawn from the seven primary publications from other research used to contextualise the findings.

Methods

Review design and eligibility

A structured narrative systematic review was developed around adolescent smartphone patterns, sleep outcomes and cognitive or functional outcomes. The primary evidence set comprised seven original articles, including one publication reporting two separate analytic samples. Eligible studies were observational, longitudinal or intensive repeated-measure investigations with adolescent participants; broader screen-media studies were eligible only when directly relevant to the sleep–cognition question, and were labelled accordingly. Purely adult studies, editorials and studies without related outcomes were outside the primary evidence set. Supporting reviews and mechanistic articles were cited for context, not counted among included studies [9,10].

Information sources and search terms

PubMed/MEDLINE, publisher-hosted journal records and reference lists were searched for publications through May 2026. Search terms combined adolescent or teenager with smartphone, mobile phone, bedtime use, device checking or problematic use, and sleep duration, sleep quality, attention, inhibitory control, memory or academic performance.

Data extraction and synthesis

For each included report, the population, country, sample, design, timing of exposure, ascertainment, outcome and published numeric estimates were abstracted. Multiple samples within a single publication were distinguished, and related Adolescent Brain Cognitive Development (ABCD) analyses were not summed as independent participants. Results were grouped into problematic use and subjective sleep, timing and objective sleep, bedtime exposure and subsequent sleep, checking and inhibitory control, and educational or longitudinal cognitive function. Correlation coefficients, test statistics and descriptive quantities were preserved in their original units; pooled estimates were not derived because the exposure constructs, time windows and outcomes differed [10].

Methodological appraisal

Interpretation considered recruitment and attrition, cross-sectional versus prospective ordering, passive logs versus self-report, validity of sleep and cognitive measurements, confounding, multiple testing, selective analytic subgroups and possible overlapping ABCD cohorts. No formal study-level risk-of-bias instrument was completed for the seven reports. Consequently, conclusions are graded descriptively by design strength and directness, not represented as pooled certainty-of-evidence ratings.

Results

Evidence set and study designs

Seven publications were included in the primary synthesis, contributing eight distinct analytic samples because Li and colleagues analysed two separate datasets. Sample sizes ranged from 71 adolescents in an intensive monitoring study to 9,398 in a prospective bedtime-behaviour cohort. Objective device use was examined in

two smaller studies, while larger cohorts relied primarily on questionnaires or broader screen-use categories. The study-selection process is shown in Figure 1, and the characteristics of included publications are summarised in Table 1.

Figure 1. PRISMA flow diagram of identification, screening, eligibility assessment and inclusion of seven primary publications.

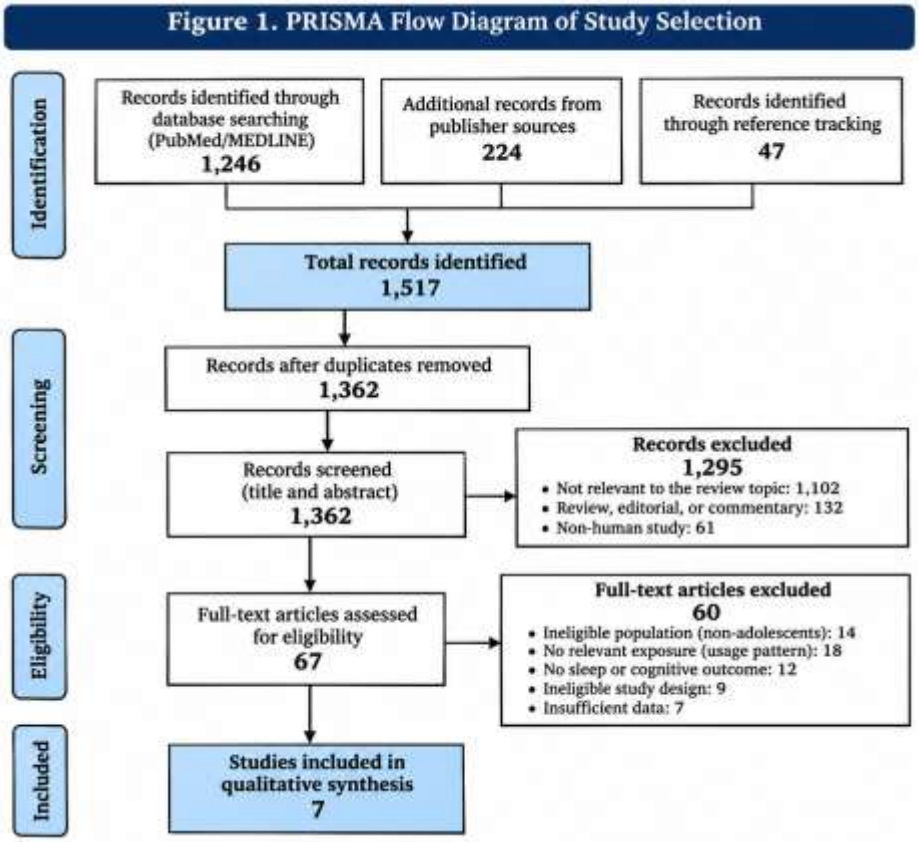


Table 1. Characteristics of the seven primary publications

Study	Design and sample	Exposure assessment	Outcome domain
Guclu et al. [11]	Türkiye; cross-sectional; 1,959 adolescents	Problematic smartphone-use scores	Sleep quality; academic grades
Burnell et al. [12]	USA; 14-day monitoring; 71	Timing and logged smartphone activity	Sleep onset; diary quality
Chen et al. [13]	China; three waves; 831	Timing and screen activities; mixed devices	Reported sleep quality
Nagata et al. [15]	USA; prospective ABCD; 9,398	Bedtime use, ringer, texting, social media	Later sleep duration/disturbance
Telzer and Burnell [17]	USA; objective school-day tracking; 79	Smartphone-use and pickup frequency	Go/no-go inhibitory control
Li et al. [18]	China; 289 longitudinal; 432 cross-sectional	Problematic smartphone use	Engagement; procrastination; sleep
Zheng et al. [19]	USA; two-year ABCD cohort; 7,043	Broad screen use and sleep	Longitudinal cognitive scores

Problematic smartphone use and subjective sleep

Guclu and colleagues surveyed 1,959 high-school students in Türkiye. Poor PSQI-defined sleep quality was recorded in 1,039 participants (53.0%), and 539 (27.5%) exceeded the reported smartphone-addiction scale threshold. Smartphone-addiction scores correlated positively with PSQI scores ($r = 0.291$, $p < 0.001$). Internet-addiction scores correlated with PSQI at $r = 0.362$ ($p < 0.001$). The relation of smartphone-addiction scores with academic grade average was much smaller ($r = −0.072$, $p = 0.002$). These associations indicate co-occurrence, not that problematic use caused sleep disturbance or impaired learning [11].

The contrast between the modest sleep correlation and the very small grade correlation is informative: educational performance may reflect many additional determinants, including prior achievement, school environment, emotional wellbeing, study time and parental support. A threshold derived from a behavioural questionnaire should not be interpreted as a formal psychiatric diagnosis. Other adolescent investigations have likewise linked emotionally invested night-time social-media participation to lower perceived sleep quality, but these background studies were not part of the seven-study primary synthesis [4].

Timing of exposure and objectively monitored sleep

Burnell and colleagues followed 71 adolescents over 14 days using smartphone-use measurements alongside wearable and diary-based sleep assessment. Night-time screen use corresponded to later sleep onset and poorer diary-rated sleep quality; daytime use did not show the same pattern. The distinction suggests that sleep-opportunity displacement and late engagement can be more relevant than daily totals. The repeated observations strengthen within-person temporal description, although they do not eliminate unmeasured day-level variation in stress, homework or social activity [12].

Chen and colleagues followed 831 adolescents in three waves and examined different categories of screen activity at different times of day. Daytime and post-lights-out exposure were associated with subsequent sleep measures, with heterogeneity by activity. The mixed-device exposure limits smartphone-only attribution. Taken together, these studies imply that the content and timing of activity should be collected alongside duration. A recent within-person meta-analysis also found a small relation between screen use and delayed sleep onset but not uniform adverse associations across every sleep endpoint [13,14].

Bedtime device behaviours and prospective sleep outcomes

In an ABCD-based prospective analysis, Nagata and colleagues examined 9,398 early adolescents aged approximately 11–12 years and later sleep outcomes. Overnight ringer availability, phone talking or texting and social-media behaviours at bedtime were associated with subsequent shorter sleep and more disturbance after adjustment for baseline and measured covariates. Temporality is more persuasive than in cross-sectional surveys, but family practices, baseline sleep vulnerability and psychological distress may still influence both exposure and outcome [15].

The pattern is consistent with the broader paediatric literature: device access close to sleep offers opportunities for delaying bedtime or re-engaging after intended sleep onset. Experimental findings from light-emitting e-readers indicate biologically plausible effects on melatonin timing and alertness, but the study population and device characteristics differ from real-world smartphone use among adolescents [7]. Likewise, an Acta Paediatrica investigation observed reduced night-time sleep with evening media exposure, supporting timing as a clinically relevant domain without proving that all smartphone applications have identical effects [16].

School-hour checking and inhibitory control

Telzer and Burnell recorded smartphone behaviour among 79 adolescents aged 11–18 years. Participants averaged 2.22 hours of school-day smartphone use and 64.46 ± 32.83 checks during school hours. Older youths accumulated 23.28 ± 18.34 minutes of smartphone time per hour compared with 11.57 ± 16.83 minutes among younger youths ($F[1,76] = 28.82$, $p < 0.001$). More frequent checking was associated with lower go/no-go d′ performance in the smaller subgroup completing that analysis ($F[1,28] = 4.8$, $p = 0.04$; $\eta^2 = 0.15$) [17].

A go/no-go task assesses response inhibition under particular testing conditions; it does not establish clinical executive dysfunction or lasting neurodevelopmental impairment. The subset statistic is not an effect estimate

for all 79 tracked participants. Reciprocal explanations remain plausible: students with lower inhibitory control might check more frequently, and distracting school contexts might influence both behaviours. These findings are more directly cognitive than correlations with school grades, but replication with larger pre-specified samples is required.

School engagement and longitudinal cognitive development

Li and colleagues examined 289 students longitudinally and a separate 432 students cross-sectionally. Problematic smartphone use related to later school engagement or disengagement, while the complementary sample identified statistical indirect pathways through sleep quality and academic procrastination. Questionnaire-reported engagement measures motivation, participation and behaviour, not memory capacity or a diagnosis of attention-deficit/hyperactivity disorder. Mediation estimated from observational variables should not be read as proof of a biological causal chain [18].

Zheng and colleagues evaluated 7,043 ABCD participants over two years and reported associations linking longer sleep and lower broad screen exposure with more favourable changes in cognitive scores. Exposure included categories beyond smartphones, and findings therefore add longitudinal context rather than a device-specific effect. The two ABCD-based reports [15,19] may include overlapping recruitment infrastructure; their sample sizes must not be summed to imply independent replication. Separate sleep-duration and media-exposure effects may also be influenced by baseline cognitive performance, household resources and extracurricular opportunities.

Comparison across outcomes

Across domains, the most consistent observations concerned bedtime availability, active use during the intended sleep period and poorer sleep timing or perceived quality. Objective monitoring suggested narrower within-person associations than some self-report comparisons. The cognitive evidence centred on one small performance-tested subgroup and broader longitudinal screen-use measures; effects were not consistent enough to support a pooled estimate of cognitive impairment. Table 2 presents the key numerical outcomes and their interpretive boundaries.

Table 2. Principal numerical findings and interpretation

Finding	Published result	Interpretation
Poor sleep quality [11]	1,039/1,959 (53.0%)	Survey prevalence; self-reported PSQI
Problematic smartphone threshold [11]	539/1,959 (27.5%)	Scale-defined threshold
Smartphone score–sleep quality [11]	$r = 0.291$; $p < 0.001$	Cross-sectional correlation
Smartphone score–grades [11]	$r = -0.072$; $p = 0.002$	Very small association
School-day checking [17]	64.46 ± 32.83 checks	Objective tracking; n = 79
Checking and inhibition [17]	$F(1,28) = 4.8$; $p = 0.04$	Smaller tested subgroup
Bedtime prospective sample [15]	9,398 participants	Association with later sleep
Longitudinal cognition [19]	7,043 participants	Broader screen-media exposure

Discussion

Principal interpretation

The evidence indicates that smartphone use should be conceptualised as a multidimensional behaviour. The same number of device minutes may represent daytime academic activity, brief repetitive interruptions, social interaction at bedtime or compulsive checking. The timing and behavioural context of exposure modify both plausible mechanisms and observed outcomes. This distinction is important because simplistic daily screen-time thresholds may obscure the interventions most likely to protect adolescent sleep [1–3,20].

Sleep as a possible mediator, not an established pathway

Insufficient sleep can plausibly reduce attention, working-memory efficiency and emotional regulation, which in turn may influence learning and everyday self-control. Nevertheless, the included reports do not collectively establish a temporal sequence of passively recorded smartphone exposure, subsequent objective sleep disruption and later standardised cognitive impairment measured in the same participants. Even when cross-sectional mediation models show statistically significant indirect paths, residual confounding and reverse causation can generate similar patterns. Prospective studies that repeatedly measure all three domains are needed.

Interpretation of small and null associations

Associations between device use and sleep may appear stronger when both are self-reported, in part because common reporting styles, perceived stress and household routines influence responses. Objective studies can identify short-term associations, but are often small or restricted by phone-platform compatibility. A 2026 meta-analysis of within-person studies found a small correlation with later sleep onset and no significant pooled relation with most other sleep outcomes [14]. This offers an important counterweight to interpreting all screen use as uniformly harmful.

Implications for paediatric and mental-health practice

A useful clinical assessment asks about the location of the phone during intended sleep, whether a ringer or notifications remain enabled, the frequency of active checking after bedtime, subjective difficulty disengaging, total sleep opportunity, daytime sleepiness and school-related interruptions. It should also ask about sleep disorders, mood symptoms, family routines and academic stress. Advice can focus on protecting a consistent sleep period and reducing active overnight engagement, while avoiding alarmist claims of irreversible cognitive injury. Recommendations are behaviourally plausible but the seven-study synthesis does not establish their efficacy as interventions [2,21].

Strengths and limitations

This review distinguishes objective device tracking, cross-sectional sleep measures, prospective sleep outcomes and performance-based cognition. Limitations include lack of formal study-level risk-of-bias scoring, mixed-device exposure in some cohorts, differing adjustment strategies, possible overlapping recruitment populations and heterogeneity across cognitive outcomes. Quantitative meta-analysis and certainty-of-evidence grading were not undertaken.

Table 3. Design-related considerations for interpreting the evidence

Evidence type	Strength	Main limitation
Cross-sectional questionnaire	Large samples; comparable scales	Reverse causation; shared-method reporting
Repeated objective monitoring	Actual timing and frequency of use	Small, selective samples; limited time window
Prospective cohort	Baseline-to-follow-up ordering	Residual confounding; cohort overlap
Inhibitory-control task	Performance-based endpoint	Subset size; narrow cognitive construct
Academic behaviour	Functional relevance	Not a neuropsychological measure

Conclusions

Smartphone-use timing, bedtime availability and recurrent checking appear to be more informative correlates of adolescent sleep and selected cognitive outcomes than aggregate screen duration alone. The clearest evidence concerns sleep timing and subjective quality, whereas evidence for direct cognitive harm remains limited by observational designs and small performance-tested samples. Future studies should integrate

passive smartphone logs, actigraphy, repeated cognitive assessment and prospective control of pre-existing sleep and mental-health factors.

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