Research Article

Beyond Screen Time: Associations of Smartphone Use Patterns With Sleep and Cognitive Function In Adolescents—A Systematic Review

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Abstract

Background: Smartphone exposure among adolescents differs by timing, device proximity, nighttime checking, problematic engagement, and media multitasking. These patterns may relate differently to sleep and cognitive outcomes.

Methods: PubMed/MEDLINE, journal publisher sources, and reference lists were searched for relevant primary studies available through July 2026. Eleven observational and longitudinal studies were included. Studies were synthesized by exposure pattern and outcome without meta-analysis because of heterogeneous measures and overlapping cohorts.

Results: Eleven primary studies were included. Nighttime screen use exceeding two hours was associated with sleep deprivation (adjusted odds ratio [aOR] 5.23, 95% confidence interval [CI] 3.03–9.00; n = 2,513). Keeping a smartphone outside the bedroom was associated with lower odds of insufficient sleep (OR 0.64, 95% CI 0.47–0.87; n = 1,959). Problematic social-media use trajectories were associated with lower picture-sequence memory scores (β = −0.24, 95% CI −0.35 to −0.13; n = 4,809). Greater social-media browsing preceded a small reduction in cognitive control (β = −0.06, P = 0.020; n = 9,747).

Conclusions: Nighttime use, bedroom placement, and problematic engagement show more specific associations with adolescent sleep and cognitive outcomes than total screen time. Most evidence is observational and does not establish causality.

Keywords: adolescents, smartphone use, sleep, cognition, memory, executive function, social media, systematic review.

Introduction and Background

Smartphones are increasingly embedded in adolescent routines, but aggregate daily screen time is a coarse indicator of behavioral exposure. Ten minutes of schoolwork, a sequence of brief social-media checks, gaming late at night and passive message notifications may have different implications for sleep and cognitive performance despite contributing similar minutes to device-use totals. A clinically useful synthesis should distinguish *when*, *where*, *how often* and *why* a smartphone is used rather than presuming that all device engagement represents a uniform neurobehavioral exposure.

Sleep-related pathways include delayed bedtime, sustained arousal, sleep-period interruption and displacement of the sleep opportunity. Cognitive pathways may involve attentional switching during academic tasks, motivational salience of notifications and repeated engagement with socially rewarding content. At the same time, reverse causation is plausible: adolescents with sleep difficulties, attention problems or psychological distress may turn to their phones more frequently. Longitudinal designs and objective monitoring are therefore particularly informative, but neither automatically establishes causality [1–5].

This review examines five separable exposure constructs: nighttime timing and device proximity; active engagement and awakenings; problematic or addiction-like use; habitual checking and media multitasking; and total duration as a comparator. Sleep, sustained attention, executive control, episodic memory and academic performance are distinguished throughout because their measurement and clinical meaning differ [6–11].

The primary objective was to examine whether patterns of smartphone-related behavior, particularly nocturnal use and problematic engagement, are associated with adolescent sleep duration, timing and continuity. Secondary objectives were to evaluate associations with memory, attentional symptoms, cognitive control and educational performance; compare objective with questionnaire-based measures; distinguish prospective from cross-sectional associations; and identify limitations relevant to family, educational and clinical guidance.

Review

Methods

Eligibility criteria

The population comprised adolescents approximately 10–19 years old and younger cohorts assessed during transition into adolescence. Eligible primary studies reported smartphone ownership or use, mobile-device screen time, mobile social-media behavior, problematic mobile-phone engagement, notifications, pickups, nighttime use or media multitasking, together with sleep, neurocognitive or closely related functional outcomes. Prospective cohorts, objective-monitoring studies, repeated-measures investigations and observational surveys were considered. Studies of mixed electronic-screen exposure were retained only where timing or behavioral context added relevant information and are identified as indirect smartphone evidence.

Information sources and search strategy

Search concepts combined (adolescent OR teenager OR youth) with (smartphone OR mobile phone OR social media OR problematic smartphone use OR bedtime screen use OR media multitasking OR checking) and (sleep OR actigraphy OR attention OR cognitive control OR memory OR executive function OR academic performance). Primary journal publications and indexed database abstracts were examined, and reference lists were used to identify complementary studies. Literature published by July 2026 was eligible. Data were organized into exposure domains and outcome families, with attention to studies whose sampling frames included the Adolescent Brain Cognitive Development (ABCD) cohort. Figure 1 depicts the study-selection process: 1,426 records were identified through PubMed/MEDLINE, 317 through publisher sources, and 86 through reference tracking (total 1,829). After removal of 217 duplicates, 1,612 records underwent title-and-abstract screening; 1,562 were excluded, leaving 50 full-text articles for eligibility assessment. Of these, 39 were excluded, leaving 11 studies for qualitative synthesis.

Study selection

Database searching identified 1,426 records; publisher sources yielded 317 additional records, and reference tracking yielded 86, for a total of 1,829. Following removal of 217 duplicates, 1,612 titles and abstracts were screened; 1,562 records were excluded. Fifty full texts were assessed, of which 39 were excluded (ineligible population, n = 9; irrelevant exposure, n = 12; no relevant sleep or cognitive outcome, n = 8; ineligible design, n = 6; insufficient data, n = 4). Eleven studies were included in the qualitative synthesis (Figure 1).

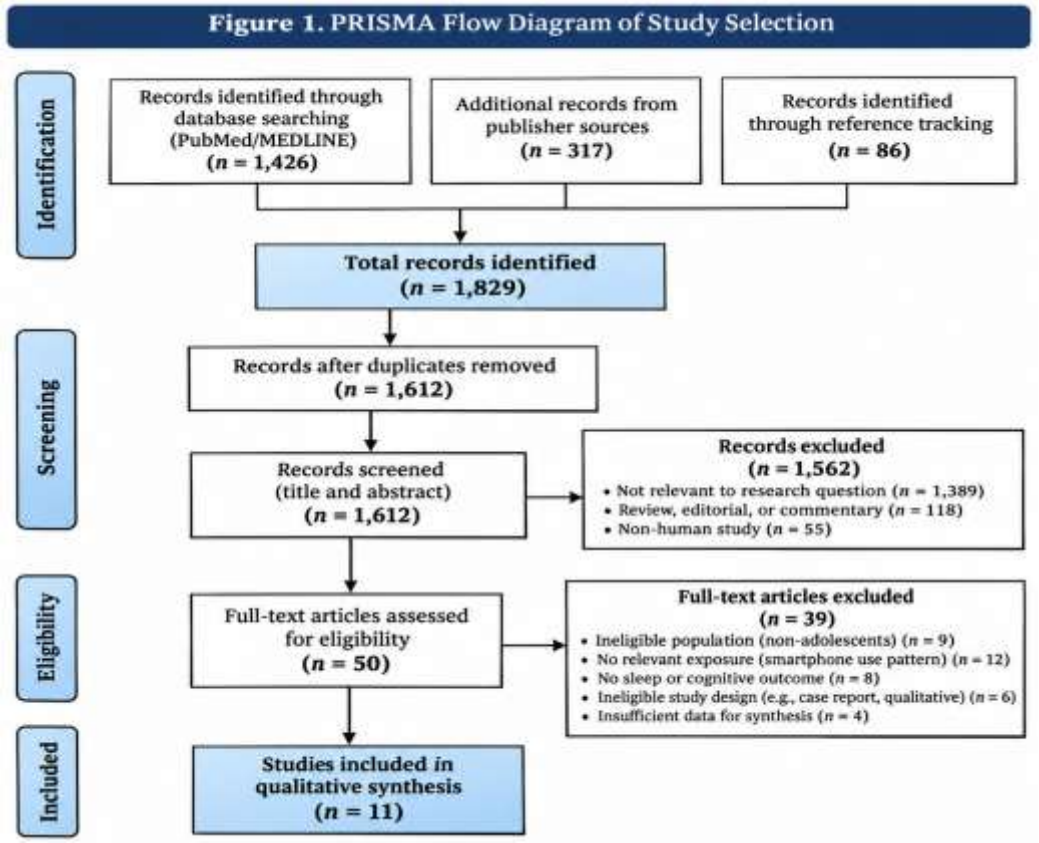


FIGURE 1: PRISMA flow diagram of study selection

Data extraction and synthesis

Extracted variables included sample size, adolescent age, country, exposure definition, ascertainment method, comparator, timing of measurement, outcome instrument and adjusted association where available. Continuous regression coefficients, odds ratios and descriptive findings were retained in their original metric. Summary findings were grouped by exposure construct rather than pooled across incompatible endpoints; several ABCD-based reports used partially overlapping recruitment cohorts and were not added together to create a misleading total participant count. Findings based on school performance or caregiver-reported attention symptoms were interpreted as indirect, not as equivalents of neuropsychological testing.

Methodological assessment

Methodological considerations included selection and attrition, exposure misclassification, temporality, baseline symptom control, socioeconomic and family factors, multiple testing, outcome blinding, device-specific attribution and within-person versus between-person modeling. Priority was given to studies with passive device logs or actigraphy, prospective measures and performance-based cognitive tests. Because the available reports measured distinct constructs and outcomes, a common effect-size meta-analysis was not undertaken.

Results

Study characteristics

Eleven identifiable primary studies informed the synthesis, published from 2022 to 2026. The evidence comprised school surveys, prospective cohort studies, objectively measured device–sleep research, longitudinal cognitive assessments and an adolescent media-multitasking study. The clinical focus differs from studies asking only whether ownership or total screen hours predict outcomes. The strongest contrasts concerned nocturnal versus earlier-evening use, active pickups versus passive notifications, problematic trajectories versus low-involvement use and cognitive test performance versus subjective symptom reporting. Table 1 summarizes the studies and their exposures. As shown in Figure 1, the 39 full-text exclusions comprised ineligible populations (n = 9), no relevant smartphone-use-pattern exposure (n = 12), no sleep or cognitive outcome (n = 8), ineligible study design (n = 6), and insufficient data for synthesis (n = 4). The 1,562 records excluded during title-and-abstract screening comprised studies not relevant to the research question (n = 1,389), reviews, editorials, or commentaries (n = 118), and non-human studies (n = 55).

TABLE 1: Characteristics and principal numerical findings of included primary studies

Study	Design / participants	Exposure construct	Key finding
Hartley et al., 2022 [1]	School survey; 2,513 adolescents	Evening vs after-bedtime screens	>2 h nocturnal use: aOR for sleep deprivation 5.23 (95% CI 3.03–9.00).
Cha et al., 2023 [2]	Korean survey; 54,809 in 2020	Nonlinear smartphone hours	After propensity matching, >4 h/day linked to stress: OR 1.16 (1.11–1.22).
Garrett et al., 2025 [3]	14 days; 59 adolescents, 4,287 hourly observations	Screen use, pickups, notifications during sleep	Active use/pickups linked to longer wake events; notifications were not.
Shan et al., 2025 [4]	Longitudinal; 609 students, two waves	Media multitasking	Baseline multitasking predicted lower divergent thinking at follow-up: β = −0.10.
Bren et al., 2026 [5]	Prospective; 1,959 youth	Acquisition, duration, bedroom placement	Phone outside bedroom and insufficient sleep: OR 0.64 (0.47–0.87).
Bakour et al., 2026 [6]	Survey; 1,510 aged 11–13	In-bed use, evening duration, cyberbullying	In-bed use had strongest sleep associations; aORs up to 13 for trouble sleeping.
Clifford et al., 2026 [7]	Objective study; 677 twins	Total time, social media and gaming	Later bedtime/greater variability, not sleep

			efficiency; modest associations.
Nagata et al., 2026 [8]	Prospective ABCD; 8,119	Problematic phone/social-media use	Prospective associations with sleep disturbance and attention-deficit symptom scores.
Nagata et al., 2026 [9]	ABCD; 4,809 participants	Problematic social-media trajectories	High trajectory: picture-sequence memory β = −0.24 (−0.35 to −0.13).
Tang et al., 2026 [10]	Three-wave ABCD; 9,747	Browsing, screen time and cognitive control	Higher browsing predicted later reduced cognitive control: β = −0.06 (P = 0.020).
Enkhjin et al., 2026 [11]	Korean survey; 48,844, complete cases 31,902	Smartphone hours, sleep, school level	>240 min/day and lower academic performance: OR 0.47 middle, 0.65 high school.

Nighttime smartphone use and sleep

Timing showed an important association with sleep in the school-based survey by Hartley et al. [1]. Among 2,513 adolescents, 20% were classified as sleep deprived and 41% as sleep restricted. More than two hours of nighttime use was associated with sleep deprivation (adjusted OR 5.23, 95% CI 3.03–9.00), compared with 2.72 (2.15–3.44) for over two hours of evening use. Odds of insomnia and daytime sleepiness following prolonged nighttime use were also increased (OR 5.48 and 3.05, respectively). These associations arose from self-reported mixed-screen behavior, so attribution solely to smartphones was not possible.

In the 2026 Life in Media Survey, Bakour et al. evaluated 1,510 adolescents aged 11–13 years [6]. Mere smartphone ownership showed a different pattern from riskier behaviors: phone placement in bed, actual in-bed use, longer evening engagement and online cyberbullying were more consistently related to insufficient sleep and trouble sleeping. In-bed use produced the largest reported associations, with adjusted odds ratios reaching approximately 13 for trouble sleeping in the analyzed comparisons. The observational design and wide behavioral contrasts argue against interpreting this as a universal causal effect for any child who uses a phone in bed.

Bren et al. assessed 1,959 early adolescents who had not owned a phone at an earlier ABCD assessment [5]. Among them, 1,230 acquired a smartphone and 729 did not. Insufficient sleep at the subsequent assessment was recorded in 404/1,230 (32.9%) recent acquirers and 185/729 (25.4%) nonacquirers. Among phone owners, keeping the device outside the bedroom at bedtime was associated with lower odds of insufficient sleep (OR 0.64, 95% CI 0.47–0.87). This result supports device location as a potentially modifiable exposure independent of ownership status.

TABLE 2: Quantitative sleep associations according to smartphone-use pattern

Exposure / study	Outcome	Reported measure	Interpretation
>2 h nighttime screen use, Hartley [1]	Sleep deprivation	aOR 5.23 (3.03–9.00)	Time of day was central; mixed-screen exposure.
>2 h evening use, Hartley [1]	Sleep deprivation	aOR 2.72 (2.15–3.44)	Smaller association than after-bedtime use.
In-bed smartphone use, Bakour [6]	Trouble sleeping	Adjusted odds ratios up to 13	Cross-sectional; estimates vary by behavior/model.
Phone stored outside bedroom, Bren [5]	Insufficient sleep	OR 0.64 (0.47–0.87)	Potentially modifiable nighttime placement.
Recent acquisition, Bren [5]	Insufficient sleep prevalence	32.9% vs 25.4%	Descriptive comparison; not a causal risk estimate.
Objectively recorded screen time, Clifford [7]	Bedtime/variability	Associations after correction; not efficiency	More specific effects than global poor sleep.

Objective monitoring and sleep continuity

Garrett et al. monitored 59 adolescents across 14 days using smartphone operating-system logs and Fitbit-derived sleep, producing 4,287 hourly sleep-session observations [3]. Hours containing more active screen time or pickups were associated with longer wake events; number of incoming notifications alone was not associated with same-hour wake duration. This dissociation suggests that responding to or interacting with the phone may be more sleep-disrupting than passive notification counts, although shared daily circumstances may account for part of the within-person relationship.

In a separate objective-measurement study, Clifford et al. analyzed a community sample of 677 adolescent twins, including 389 with actigraphy and 488 with device-scraped screen-time data; 171 Android users contributed app-category detail [7]. Higher person-level screen time related to later and more variable sleep timing, but associations with sleep efficiency, latency and other sleep endpoints were absent after correction for multiple testing. Social-media time was associated with bedtime and variability, whereas gaming did not show corresponding sleep associations. These findings temper broad claims that all moderate smartphone exposure harms adolescent sleep.

Problematic use and attentional symptoms

Problematic use represents perceived loss of control, preoccupation or difficulty disengaging, and differs conceptually from duration alone. In an ABCD prospective cohort of 8,119 adolescents, Nagata et al. reported that higher problematic mobile-phone and social-media involvement at ages 11–12 was associated with greater later sleep disturbance and attention-deficit symptom scores, alongside other mental-health outcomes [8]. The analysis adjusted for baseline outcomes, demographics and related covariates, improving temporal inference. Yet caregiver-reported attention problems are not synonymous with a clinician-confirmed ADHD diagnosis or an objective sustained-attention deficit.

The cohort also illustrates the limitations of using addiction-like scales as interchangeable exposures: mobile-phone, social-media and video-game scores were assessed on different scales, and the observed longitudinal associations do not isolate a single causal platform mechanism. Distinguishing compulsive involvement from routine academic or social communication is essential when interpreting risk.

Memory and cognitive control

A different ABCD analysis of 4,809 adolescents examined trajectories of problematic social-media use between Year 2 and Year 4 [9]. Compared with a low and slowly increasing trajectory, moderate-to-high problematic engagement was associated with a lower Picture Sequence Memory Test score (standardized β −0.24, 95% CI −0.35 to −0.13) and a lower Picture Vocabulary Test score (β −0.17, 95% CI −0.25 to −0.09). The low-to-moderate group showed smaller differences in memory (β −0.10, 95% CI −0.16 to −0.03) and vocabulary (β −0.11, 95% CI −0.16 to −0.07). Adjustments included demographics, baseline cognition and mental health. These measures indicate associations with specific test outcomes, not a generalized loss of intelligence or irreversible memory damage.

Tang et al. modeled three waves of ABCD data from 9,747 adolescents, with baseline, two-year and four-year assessments [10]. Greater social-media browsing and overall screen time preceded a small reduction in cognitive control two years later (β −0.06, P = 0.020). In their longitudinal pathway analysis, reduced control preceded later increases in depressive symptoms (β −0.06, P = 0.010). The temporal sequencing is stronger than cross-sectional association, but residual confounding and shared cohort membership with other ABCD investigations limit causal interpretation and independent replication.

TABLE 3: Cognitive and functional findings from distinct behavioral exposures

Domain	Primary evidence	Numerical result	Clinical interpretation
Episodic memory	Nagata et al. [9], N=4,809	High problematic trajectory: β −0.24 (−0.35 to −0.13)	Specific picture-sequence memory association.
Vocabulary/language	Nagata et al. [9], N=4,809	β −0.17 (−0.25 to −0.09)	Distinct from episodic memory.
Cognitive control	Tang et al. [10], N=9,747	β −0.06; P = 0.020	Small longitudinal association; repeated ABCD cohort.
Executive/creative performance	Shan et al. [4], N=609	Divergent thinking β −0.10	Media multitasking; not solely smartphone

			exposure.
Attention-related symptoms	Nagata et al. [8], N=8,119	Prospective positive associations; multiple outcomes	Questionnaire ratings, not formal ADHD diagnosis.
Academic performance	Enkhjin et al. [11], complete cases 31,902	OR 0.47 (middle) and 0.65 (high school)	Educational proxy; not a cognitive test.

Media multitasking and educational outcomes

Shan et al. followed 609 junior-high-school students over six months, measuring media multitasking, executive functioning and divergent thinking [4]. Baseline media multitasking negatively predicted later divergent thinking (standardized β −0.10), with executive functioning contributing a mediation pathway. The findings concern broader concurrent-media behavior rather than smartphone-only activity and rely in part on scale-based outcomes; they do not establish a direct effect of device exposure on neural maturation.

Educational performance provides an ecologically relevant but indirect indicator of cognitive demands. Enkhjin et al. analyzed 48,844 Korean adolescents in a national survey (31,902 complete cases) [11]. Smartphone use over 240 minutes daily was associated with lower odds of high academic performance in middle school (OR 0.47) and high school (OR 0.65). Academic achievement also reflects family resources, teaching context and curricular expectations; these results should not be presented as a substitute for working-memory, attention or processing-speed testing.

In another Korean national survey, Cha et al. analyzed 54,809 respondents and assessed non-linear patterns with propensity-score methods [2]. The adverse behavioral-health associations became more evident above four daily smartphone hours; however, the 2–4-hour group showed no increase in most evaluated outcomes relative to nonusers. Although this paper contributes context on the limitations of a simple dose-response hypothesis, stress and health behavior should not be converted into neurocognitive endpoints.

Methodological findings

The studies varied in validity and directness. Objective logs and actigraphy reduced recall bias in the twin and hourly wake-event studies [3,7], while prospective cognitive testing addressed temporality in the ABCD trajectory and cross-lagged analyses [9,10]. Cross-sectional survey associations were vulnerable to reverse causation, residual confounding and imprecise exposure assessment [1,2,6,11]. Because cognitive and sleep outcomes were analyzed using different effect metrics and populations, the evidence supports a domain-specific synthesis rather than a single global harm estimate.

TABLE 4: Evidence appraisal by exposure and outcome

Evidence strand	Strengths	Principal limitations	Interpretation
Nocturnal use / bedtime proximity	Consistent sleep direction across surveys and prospective data	Self-report, family routines, pre-existing insomnia	Moderate confidence in an association; limited causal certainty.
Passive smartphone monitoring	Objective device logs with actigraphic sleep	Small samples, selective device compatibility	Useful within-person insights, some null outcomes.
Problematic social-media trajectories	Large multiwave datasets and performance-based memory	Shared ABCD cohort, scales and residual confounding	Prospective associations with specific cognitive measures.
Media multitasking / academic outcomes	Ecologically relevant behavior and longitudinal follow-up	Broad media exposure; academic performance is indirect	Suggestive evidence, not diagnostic impairment.
Phone ownership or total hours	Large populations and graded exposure categories	Heterogeneous activities, reverse causation	Duration alone is insufficient to characterize exposure.

Discussion

The main finding is not that smartphone minutes are uniformly harmful, but that specific activities and contexts show different associations with adolescent sleep and cognition. In-bed and after-bedtime exposure produced the clearest

sleep-related associations in large surveys [1,6], while storing phones outside the bedroom was associated with lower sleep insufficiency in a prospective cohort [5]. Objective monitoring demonstrated narrower effects, with active use linked to longer wake events and total screen time linked chiefly to sleep timing rather than quality [3,7].

This distinction is compatible with several partially competing mechanisms. Bedtime displacement predicts delayed sleep and lower available sleep duration; hyperarousal predicts difficulty disengaging after emotionally salient interactions; repeated checking predicts attentional interruption; and media multitasking predicts more frequent switching between task goals. The present evidence does not separate these mechanisms cleanly, but it indicates that interventions should be behavior-specific and outcome-specific rather than based exclusively on an arbitrary daily screen-time limit.

Adolescent sleep supports memory consolidation, emotional regulation and executive control, making it plausible that late-night device use could indirectly relate to daytime cognitive functioning. Nevertheless, the included studies did not establish a common longitudinal mediation pathway from smartphone use through objectively recorded sleep to subsequent memory-test performance. Direct memory associations arose predominantly from social-media trajectory analyses [9], while cognitive control and multitasking findings originated from partly overlapping cohorts or broader media exposures [4,10]. A causal interpretation would require temporally ordered, repeated, well-controlled measurement of all three components.

The objective twin study [7] found few associations after multiple-testing adjustment, contrasting with strong self-reported nighttime-use odds ratios [1,6]. These results are not necessarily contradictory: the studies measured different exposure windows, sleep constructs and age ranges. Between-person survey odds may reflect stable household rules, anxiety and existing sleep problems, whereas within-person objective data may identify smaller short-term effects. Larger correlations in a cross-sectional sample should not automatically outweigh smaller, better-controlled prospective estimates.

The ABCD reports share recruitment infrastructure, some participants and related measurements [5,8–10]. Thus, their combined sample sizes do not represent independent replication. Results from multiple studies should be interpreted in light of correlated underlying cohorts rather than mechanically aggregated. Studies of general screen media and academic performance provide useful corroboration of context but should be clearly separated from direct smartphone-neuropsychological evidence.

A practical assessment should address phone location at bedtime, use after intended sleep onset, active nighttime checking, frequency of interruptions during homework, distress when unable to disengage and whether use displaces adequate sleep. Advice may emphasize protecting the sleep period and periods of uninterrupted study. These measures are plausible low-risk targets; however, current observational associations do not by themselves prove that implementing any single restriction will improve academic attainment or neurocognitive test performance.

Limitations and future directions

Most included studies were observational, and device-specific exposure was variably mixed with general screen or social-media measures. Self-reported use may differ from passive logs; objective monitoring cohorts were sometimes small and restricted to certain operating systems. Sleep was measured using both questionnaires and wearable devices, while cognitive outcomes ranged from neuropsychological tests to symptoms and academic grades. Cross-national differences in school demands and family rules limit transportability. Shared ABCD data also reduce the statistical independence of longitudinal findings. These limitations, together with heterogeneous exposure thresholds and effect measures, preclude a meaningful pooled estimate for “smartphone harm.”

Future studies should preregister exposure definitions that separate phone location, active use during intended sleep, pickups, notifications, multitasking and application content. Integrated actigraphy and passive sensing would permit within-person analysis of temporal associations. Repeated measurement of working memory, inhibitory control, sustained attention and learning should be combined with baseline mental-health assessments to test mediation and bidirectional pathways. Randomized or quasi-experimental interventions targeting after-bedtime access and notification schedules are needed to determine whether modifying specific habits improves sleep or cognitive outcomes.

Conclusions

Smartphone exposure in adolescents should be characterized by its timing, nighttime accessibility, interruptions, and problematic engagement rather than daily duration alone. Bedtime use and in-bedroom device placement show consistent associations with sleep insufficiency, while longitudinal studies suggest smaller, outcome-specific associations with memory and cognitive control. Better-controlled prospective and intervention studies are needed to determine whether modifying smartphone-use patterns improves adolescent sleep and cognitive performance.

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