Research Article

Smartphone Use and Neurocognitive Functioning Among Adolescents: A Systematic Review of Cognitive and Behavioral Outcomes

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Abstract

Background: Smartphone exposure has become nearly universal during adolescence, raising concerns about its effects on sleep, attention, memory, and executive functioning during a critical neurodevelopmental period.

Objective: To systematically review published evidence on the association between smartphone exposure and adolescent neurocognitive health, with emphasis on sleep, attention, memory, and executive function.

Methods: Structured searches of databases and registers identified 1,276 records (1,268 from databases and 8 from registers). After removal of 236 duplicates, 14 records marked ineligible by automation tools, and 6 records removed for other reasons, 1,020 records were screened. Of these, 892 were excluded. A total of 128 reports were sought for retrieval, 7 were not retrieved, and 121 full-text reports were assessed. After exclusion of 106 reports for wrong population (38), inadequate outcome data (26), or non-eligible study design (42), 15 studies were included in the review. Findings were synthesized narratively across sleep, attention, memory, and executive-function domains.

Results: Fifteen primary studies were included. The most consistent evidence linked nighttime and high-frequency smartphone use with shorter sleep duration, delayed sleep onset, poorer sleep quality, and sleep disturbance. Attention-related outcomes suggested associations between frequent digital engagement and inattentive or distractible behavior, although effect measures varied across studies. Memory findings were mixed, with some longitudinal evidence linking heavier social-media exposure to lower verbal-memory performance, while small experimental work showed no clear short-term effect on overnight memory consolidation. Executive-function findings were heterogeneous and depended on whether outcomes were assessed by questionnaire, cognitive task performance, or neuroimaging correlates.

Conclusion: Current evidence most strongly supports an adverse association between nighttime smartphone exposure and adolescent sleep. Evidence for attention, memory, and executive functioning is more heterogeneous and largely observational. More longitudinal, objectively measured, and intervention-based studies are needed to clarify causality.

Keywords: smartphone exposure; adolescents; sleep duration; attention; verbal memory; working memory; inhibitory control; executive functions; media multitasking; systematic review.

1. Introduction

Adolescence is a period of rapid development in sleep regulation, social motivation, cognitive control, and learning. Smartphones integrate messaging, social networks, video platforms, games, and educational applications into an always-available device. Potential pathways linking exposure to neurocognitive outcomes include displacement of sleep, nighttime alerting and social arousal, habitual interruptions during learning, and sustained attentional switching. These mechanisms are plausible, but the extent to which observed associations reflect a causal effect of smartphones—rather than pre-existing differences in sleep, mental health, attention or family environment—remains uncertain.

Large observational surveys have repeatedly linked electronic-device use before bedtime with short sleep and delayed sleep onset [1]. Prospective research also suggests that high-frequency digital-media engagement can precede the emergence of attention-deficit/hyperactivity disorder (ADHD)-like symptoms [2]. Yet self-reported executive difficulties and performance on standardized cognitive tasks do not always agree [3]. More recently, social-media trajectory studies have evaluated objective verbal-memory performance rather than relying only on subjective concentration ratings [4].

A rigorous interpretation requires separation of smartphones from other digital devices, duration from checking frequency, nighttime from daytime use, subjective symptom reports from cognitive testing, and correlational neural markers from clinically meaningful impairment. This review therefore evaluates sleep, attention, memory, and executive function as distinct but interacting domains.

2. Materials and Methods

2.1 Review question and eligibility

The review question was framed using population, exposure, comparator and outcomes: adolescents approximately 10–19 years of age, including cohorts assessed during the transition into adolescence; smartphone or closely related mobile/digital-media engagement; lower exposure, alternative use patterns, or within-person lower-use periods; and outcomes measuring sleep, sustained attention, attentional symptoms, working memory, learning and recall, cognitive control or executive function. Original cross-sectional, prospective cohort, intensive longitudinal, neuroimaging and experimental studies were eligible. Broader screen-media studies were retained only when informative for the domains under review and were distinguished from smartphone-specific exposure.

2.2 Search strategy and sources

Search concepts combined “adolescent” OR “teenager” OR “youth” with “smartphone” OR “mobile phone” OR “screen time” OR “social media” OR “media multitasking” and outcome terms “sleep”, “insomnia”, “attention”, “ADHD symptoms”, “memory”, “working memory”, “inhibitory control”, “cognitive flexibility”, or “executive function”. PubMed/MEDLINE-indexed records, publisher-hosted primary reports, register-linked records, and cross-referenced original publications were examined for work available through June 2026. The study-selection process followed PRISMA 2020. A total of 1,276 records were identified (1,268 from databases and 8 from registers). Before screening, 236 duplicate records, 14 records marked ineligible by automation tools, and 6 records removed for other reasons were excluded. This left 1,020 records for screening, of which 892 were excluded. One hundred twenty-eight reports were sought for retrieval; 7 were not retrieved. Full-text assessment was completed for 121 reports, and 106 were excluded for wrong population (38), inadequate outcome data (26), or non-eligible study design (42). Fifteen studies were included in the final review [5].

Figure 1 summarizes the PRISMA 2020 study-selection process for this review.

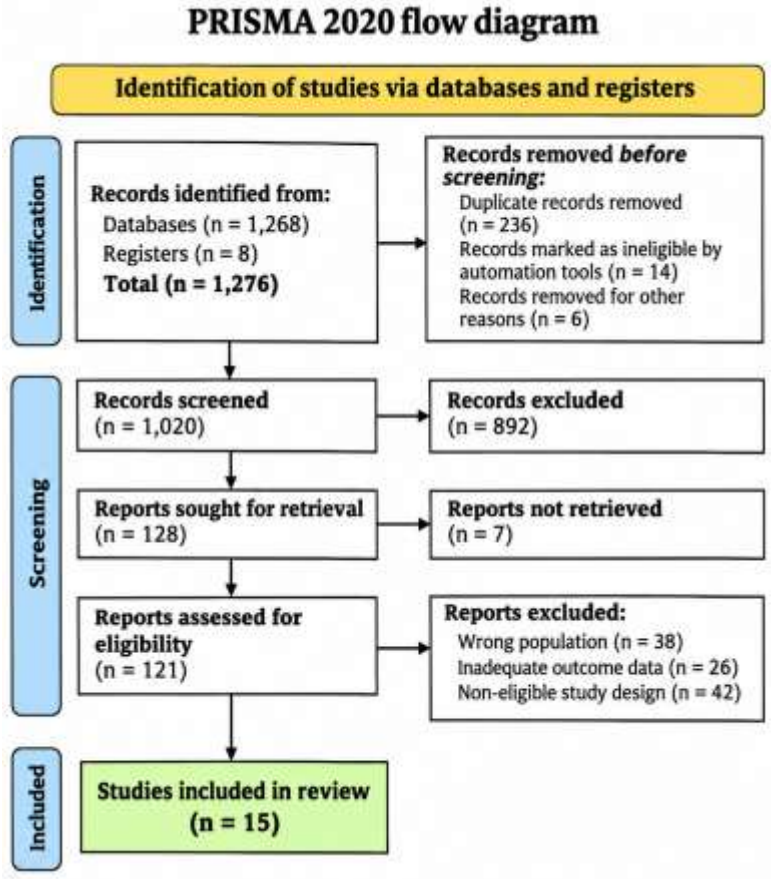


Figure 1. PRISMA 2020 flow diagram for study selection.

2.3 Outcomes, extraction, and evidence synthesis

The primary outcomes were objectively or subjectively measured sleep duration/quality, attention-task performance or ADHD symptom measures, verbal or spatial memory measures, and executive-function task or questionnaire scores. Study year, population size and age, exposure operationalization, study design, cognitive instrument, reported numerical association and major confounding limitations were abstracted. Evidence was organized by domain and by timing, content and intensity of exposure. Because the studies used non-comparable exposures, measurements and statistical models, a common pooled effect was not calculated.

2.4 Methodological appraisal

Study validity was evaluated using design-based considerations including selection bias, temporal ordering, reliance on self-report, reverse causation, residual confounding, attrition, task reliability, objective device-use measurement and generalizability. For experiments, sample size and exposure duration were considered. Studies using overlapping Adolescent Brain Cognitive Development (ABCD) cohorts were interpreted as related analyses, not independent participant samples.

3. Results

Study selection

A total of 1,276 records were identified through databases and registers. After removal of 236 duplicates, 14 records marked as ineligible by automation tools, and 6 records removed for other reasons, 1,020 records underwent title and abstract screening. Of these, 892 records were excluded. One hundred twenty-eight reports were sought for retrieval, and 7 were not retrieved. Full-text assessment was completed for 121 reports. A total of 106 reports were excluded because of wrong population (38), inadequate outcome data (26), or non-eligible study design (42). Fifteen studies met the eligibility criteria and were included in the qualitative synthesis (Figure 1).

3.1 Characteristics of the evidence

Fifteen primary investigations provided directly relevant observations across the four outcome domains. Six examined sleep or bedtime behavior, three addressed attention-related outcomes, three contributed principal memory evidence, and three examined executive control or neural processes; several studies informed more than one domain. The studies spanned school surveys, prospective cohorts, passive phone sensing, laboratory neuropsychology, brain-imaging cohorts, and a controlled presleep exposure experiment. Exposure was measured directly in only a subset; the remainder used self-reported smartphone activity, social-media patterns, or broader electronic-media engagement.

Table 1. Characteristics of included primary investigations

Study [ref]	Design and sample	Exposure	Outcome and principal observation
Hysing et al., 2015 [1]	Cross-sectional; 9,846, ages 16–19	Bedtime electronic devices and daytime screens	More bedtime use linked to short sleep and delayed sleep onset.
Ra et al., 2018 [2]	Longitudinal; 2,587, mean age 15.5	High-frequency digital activities	Adjusted OR 1.10 per additional high-frequency activity for later ADHD symptoms.
Baumgartner et al., 2014 [3]	Cross-sectional; 523, ages 11–15	Media multitasking	More perceived everyday EF difficulties; mixed/null laboratory outcomes.
Nagata et al., 2026 [4]	Prospective ABCD; 7,528, baseline age 8–13	Social-media trajectories	Increasing use related to lower verbal-memory scores at year 2.
Lemola et al., 2015 [6]	Cross-sectional; 362, ages 12–17	Nighttime electronic media and smartphone ownership	Greater bedtime use associated with short sleep and sleep difficulties.
Dewi et al., 2018 [7]	Cross-sectional; 714 adolescents	Nocturnal smartphone use	Sleep disturbance correlated with nighttime use (r=0.374).
Nagata et al., 2024 [8]	Prospective ABCD; 9,398, ages 11–12	Bedtime screen behaviors	Phone ringer on, texting and social-media use preceded worse sleep at 1 year.

Burnell et al., 2024 [9]	Daily monitoring; 71, mean age 16.49	Phone-use screenshots and pickups over 14 days	Greater within-person nighttime use associated with later sleep onset.
Zhao et al., 2026 [10]	Passive sensing; 425, mean age 14.8; 7,591 nights	Smartphone use after 10 pm	Each extra above-usual minute linked to 0.43 minute less total sleep.
Poujol et al., 2022 [11]	Cross-sectional; 632, mean age 13.89	Self-reported mobile screen exposure	Higher reaction-time variability; no robust working-memory link.
Telzer & Burnell, 2026 [12]	School-based sensing; 79, ages 11–18	iPhone pickups during school	More frequent checking associated with weaker go/no-go cognitive control.
Soares et al., 2021 [13]	Birth cohort; 3,625 measured at adulthood	Television, games and computer time ages 11–18	Some positive male-specific associations with age-22 working memory; none in women.
Sennock et al., 2024 [14]	Within-subject experiment; 20, ages 12–14	45-min presleep social media versus reading	No discernible difference in sleep or memory consolidation.
Arekatla et al., 2026 [15]	Longitudinal ABCD; 9,931	Texting, gaming and TV screen time	Greater use linked to lower working-memory fMRI neural-signature scores.
Maza et al., 2023 [16]	Longitudinal imaging; 169 early adolescents	Habitual social-media checking	Different trajectories of neural sensitivity to social anticipation.

3.2 Sleep: duration, onset, and nighttime continuity

Sleep findings showed the most consistent direction of association. In a Norwegian survey of 9,846 adolescents aged 16–19 years, more extensive electronic-device use was associated with shorter sleep duration, prolonged sleep-onset latency and increased sleep deficiency. The report gave an odds ratio of 2.70 (95% CI 2.14–3.39) for fewer than five hours of sleep in relation to a specific computer-use exposure, emphasizing that the measure was electronic media broadly rather than smartphone time alone [1].

In 362 adolescents, Lemola and colleagues found that smartphone ownership was associated with more communication and internet use in bed and later bedtimes. Nighttime electronic-media engagement was linked to short sleep and sleep difficulties, although ownership itself was not directly associated with all measured sleep disturbances [6]. A separate 714-adolescent study reported a positive correlation between nighttime smartphone use and sleep disturbance (r=0.374) [7]. Both designs relied on questionnaire-derived exposures and outcomes.

Prospective evidence adds temporal information. In 9,398 early adolescents, keeping the phone ringer activated overnight, talking or texting and social-media use at bedtime were associated with shorter subsequent sleep and greater caregiver-reported sleep disturbances at one-year follow-up, after adjustment for baseline sleep and sociodemographic characteristics [8].

Objective repeated-measures studies refined this relationship. Burnell et al. monitored 71 adolescents using phone-use screenshots and Fitbit data over 14 days and observed that excess nighttime, but not daytime, phone engagement was related to poorer same-night sleep measures [9]. In a larger 2026 intensive longitudinal study of 425 adolescents contributing 7,591 nights, Zhao et al. found that every additional minute of smartphone use after 10 pm above an individual's typical level was associated with 0.87 minute later sleep onset (95% CI 0.84–0.90) and a reduction of 0.43 minute in total sleep time (95% CI −0.47 to −0.39). Immediate presleep activity was associated with more early post-onset wakefulness [10]. This within-person evidence reduces some stable-person confounding, but it cannot fully eliminate day-specific reverse causation or differences in bedtime obligations.

3.3 Attention, distractibility, and ADHD-like symptoms

An important longitudinal study followed 2,587 adolescents initially below a significant ADHD-symptom threshold. Each additional digital-media activity used many times daily was associated with greater odds of subsequent ADHD symptoms (covariate-adjusted OR 1.10, 95% CI 1.05–1.15). Across follow-ups, the mean ADHD-symptom rate was 4.6% in adolescents without any high-frequency activities, 9.5% in those with seven such activities and 10.5% in those with 14. The digital-media index covered several platforms, not smartphone use exclusively, and symptoms were questionnaire-derived rather than new clinical ADHD diagnoses [2].

Objective cognitive tasks provide complementary findings. Among 632 adolescents (mean age 13.89 years), higher self-reported mobile screen exposure was associated with greater hit-reaction-time variability, an indicator of inattentive task performance. After covariate adjustment, an intermediate exposure group showed 17.6 ms greater variability (95% CI 3.4–31.7) than the lowest group; fluid intelligence and working memory were not significantly associated with exposure [11].

In 79 youths aged 11–18 years, objectively captured school-day smartphone use averaged 2.22 hours, with approximately 64.46 device pickups during school hours. More frequent checking was associated with lower performance on a go/no-go cognitive-control task ($F[1,28]=4.8$; $P=.04$). The sample supporting this task association was small, and the cross-sectional design cannot determine whether frequent checking reduces control or adolescents with weaker control check more often [12].

3.4 Memory and learning

Memory evidence was not uniform. In a prospective ABCD cohort of 7,528 participants, social-media-use trajectories were associated with verbal and spatial memory at the two-year assessment after adjustment for baseline cognition and other covariates. Compared with low or no use, high-increasing exposure was related to lower initial Rey Auditory Verbal Learning Test performance (B=−1.90, 95% CI −2.76 to −1.04), lower long-delay recall (B=−0.55, 95% CI −0.84 to −0.27), and lower spatial-task accuracy (B=−0.03, 95% CI −0.05 to −0.01) [4]. The cohort began at ages 8–13, so the estimates span the transition from late childhood into adolescence and represent social-media use, not smartphone-specific dose.

In contrast, the Pelotas birth cohort followed 3,625 participants with reported television, gaming and computer exposure at ages 11, 15 and 18 years, with Digit Span backward assessed at age 22. Several early-life associations in men were positive and mediated partly by IQ, while no significant associations were observed in women. Because these media modalities predated much of the modern smartphone ecosystem, they are useful as contextual evidence rather than direct tests of phone-related memory impairment [13].

Experimental evidence also cautions against simple causal interpretation. In a within-subject experiment with 20 adolescents aged 12–14 years, 45 minutes of presleep social-media use was compared with reading from a smartphone or a physical book. Sleep quality, presleep arousal and overnight memory consolidation did not differ discernibly among conditions [14]. The experiment addresses immediate exposure rather than long-term accumulation and was underpowered to exclude small effects.

3.5 Executive function and neurocognitive control

In 523 early adolescents aged 11–15 years, more frequent media multitasking corresponded to greater self-reported problems in working memory, attentional shifting and inhibition in everyday life. However, it was unrelated to performance on Digit Span and Dots–Triangles tests, and frequent multitaskers performed somewhat better at filtering irrelevant distraction on a Flanker task. This divergence suggests that behavioral ratings and brief laboratory tasks measure different components of executive functioning [3].

Recent neuroimaging studies extend the outcome scope without establishing direct clinical impairment. Using 9,931 participants in a longitudinal ABCD analysis, Arekatla et al. found associations between greater texting, gaming and television activity and lower working-memory functional MRI neural-signature scores, with sex and family context modifying some relationships. These signatures reflected task-related activation patterns and must not be interpreted as diagnoses or direct evidence of diminished everyday competence [15].

Maza et al. followed 169 early adolescents and reported different trajectories of neural responses in affective salience and cognitive-control networks among habitual versus nonhabitual social-media checkers. The measured endpoint was sensitivity to anticipated social reward or punishment, not sustained-attention accuracy or a neurodegenerative outcome [16]. Taken together, these studies support further investigation of habit formation and cognitive control, but not a uniform claim that smartphone exposure causes executive dysfunction.

Table 2. Quantitative findings central to domain-level interpretation

Domain	Primary finding	Effect estimate / sample	Interpretation
Sleep	Hysing et al. [1]	9,846 adolescents; PC exposure and <5 h sleep: OR 2.70 (95% CI 2.14–3.39)	Broad electronic-device association; cross-sectional.
Sleep	Dewi et al. [7]	714 adolescents; nighttime use vs sleep disturbance r=0.374	Self-report correlation; not causal.
Sleep	Zhao et al. [10]	425 adolescents, 7,591 nights; +1 min after 10 pm -> −0.43 min	Within-person passive measurement; precise time-specific association.

		sleep	
Attention	Ra et al. [2]	2,587 adolescents; adjusted OR 1.10 (95% CI 1.05–1.15) per digital activity	ADHD-like symptom association, not clinical diagnosis.
Attention	Poujol et al. [11]	632 adolescents; adjusted reaction-time variability difference +17.6 ms (95% CI 3.4–31.7)	Attention-task signal with no corresponding robust WM association.
Attention / EF	Telzer & Burnell [12]	79 youths; go/no-go F(1,28)=4.8; P=.04	Small objectively monitored sample.
Memory	Nagata et al. [4]	7,528 youths; RAVLT initial trial B=−1.90 (95% CI −2.76 to −1.04)	Longitudinal association of social-media trajectory, not phone-specific effect.
Memory	Sennock et al. [14]	20 adolescents, 45-min exposure; no discernible memory-consolidation effect	Small controlled short-term null result.
Executive function	Baumgartner et al. [3]	523 early adolescents; self-report EF association but Digit Span/task-switching null	Important mismatch between task and questionnaire endpoints.

3.6 Exposure characteristics and evidence consistency

An important distinction emerged between the quantity of screen exposure and its situational pattern. Late-evening engagement, notifications and checking immediately before sleep were more reliably associated with sleep outcomes than broad daytime totals [8–10]. High-frequency switching and checking were relevant to attentional and executive outcomes [2,3,12]. In contrast, memory-related work examined social-media trajectories or general screen categories, with heterogeneous findings across prospective and experimental designs [4,13,14].

Studies differed in baseline age, country, socioeconomic environment, sex distribution, assessment period and platform mix. Analyses of the same ABCD infrastructure were not treated as independent replications; their separate outcomes contribute breadth but may share underlying participant characteristics. Objective smartphone monitoring reduced reporting bias in the newer sleep and cognitive-control studies, whereas earlier cohorts tended to rely on retrospective use estimates.

Table 3. Methodological strengths, concerns, and interpretation by study type

Evidence approach	Key strength	Principal limitation	Implication
Large cross-sectional surveys [1,6,7,11]	Substantial sample size; broad age coverage	Self-report and reverse causation	Useful for identifying associations, not effects.
Prospective cohorts [2,4,8,13]	Exposure precedes subsequent outcome	Residual confounding; developmental changes	Improves temporal inference but cannot prove causality.
Intensive objective monitoring [9,10,12]	Device-use timestamps and repeated sleep/task measurement	Selective devices, limited samples; no randomization	Clarifies whether timing and checking matter.
Laboratory experiment [14]	Within-subject exposure comparison	20 participants; short follow-up	Direct test of short-term effect, not chronic impact.
Neuroimaging cohorts [15,16]	Neural network measures and developmental follow-up	Indirect endpoints; analytic multiplicity; shared ABCD cohorts	Hypothesis-generating neural correlates, not clinical impairment.

4. Discussion

This synthesis identified a clear gradient in the strength and interpretability of the evidence across outcomes. Sleep findings were supported by both large cohorts and smaller studies using objective phone-use and actigraphy data. Attention findings suggested associations between high-frequency activity or checking and impaired attentional control,

but effect metrics varied and most evidence remained nonexperimental. Memory and executive-function findings were less consistent, including positive, null and domain-specific relationships.

4.1 Nighttime exposure and sleep as a potential pathway

Displacement of sleep opportunity is the most direct pathway linking smartphone behaviors with neurocognitive outcomes. Messaging, social feedback, video consumption and checking can delay sleep onset; late alerts may also fragment sleep in susceptible adolescents. Because adequate sleep supports encoding, consolidation, emotional regulation and executive attention, poor sleep may mediate associations with daytime cognition. However, the studies summarized here did not consistently test formal sleep-mediated causal pathways across all four outcomes, and concurrent stress or sleep difficulties may themselves drive nighttime device use.

4.2 Attention, task interruption, and reverse causation

Frequent digital engagement may increase task switching and undermine uninterrupted study time, yet adolescents with pre-existing inattention or impulsivity could preferentially seek frequent platform rewards. Ra et al.'s prospective association [2] provides a stronger temporal signal than cross-sectional studies, while passively measured school-time checking [12] suggests that the behavior itself, not just total minutes, warrants investigation. Neither supports diagnosing ADHD on the basis of smartphone exposure.

4.3 Memory findings depend on the exposure and measurement

Longitudinal associations between higher social-media exposure and lower verbal recall [4] should be interpreted against a small experiment with no measurable overnight consolidation effect [14] and historical mixed-screen evidence with positive or null associations [13]. Differences in follow-up period, cognitive test, age and opportunity costs of time likely explain some inconsistency. Memory is not a single process: encoding, immediate recall, delayed recall, interference and short-term manipulation can respond differently to sleep disruption and media multitasking.

4.4 Executive performance is not equivalent to self-reported difficulty

Executive-function complaints reflect cumulative daily-life demands, including the burden of filtering notifications and sustaining focus in naturalistic settings. Brief tests may capture narrower performance capacity under controlled conditions. The mixed laboratory findings of Baumgartner et al. [3] and the emerging neural correlates of screen-media use [15,16] therefore should not be presented as a unified pattern of cognitive decline. Quantitative neuroimaging changes also cannot establish that an individual adolescent has clinically meaningful impairment.

4.5 Clinical and public-health implications

Assessment of adolescent digital behavior should move beyond asking only for total daily screen time. More informative questions address phone availability after bedtime, overnight alerts, late-evening engagement, checks during schoolwork, distress related to disconnection, and displacement of sleep, physical activity or in-person activity. Guidance can reasonably prioritize sleep-preserving practices and interruption-free learning periods, while avoiding unsupported claims that smartphone ownership inevitably causes memory impairment or neurological damage.

5. Limitations

Several sources of uncertainty limit causal inference. Most original studies were observational, and many exposure measures were self-reported. Smartphone use was variably combined with television, computer use, gaming or social media, limiting device-specific attribution. Baseline anxiety, depression, ADHD symptoms, socioeconomic conditions and family routines were not uniformly addressed. Self-reported sleep estimates do not necessarily agree with actigraphy. Many cognition analyses used indirect proxies or neuroimaging signatures rather than clinically interpretable outcomes. Cohort overlap within ABCD-based reports creates dependence among apparently separate results. Lastly, platform algorithms and technology change rapidly, reducing comparability across publication eras.

6. Implications for Future Research

Future research should combine consented passive sensing with actigraphy, validated sleep measures, standardized attention testing, RAVLT or equivalent memory measures, and tasks assessing inhibition and working memory. Preregistered studies should distinguish exposure timing, app category, notification frequency and active versus passive engagement. Repeated measurements before and after device-use interventions are needed to separate within-person effects from stable vulnerabilities. Trials of nighttime notification reduction or protected study periods may offer practicable causal tests. Analyses should explicitly test sleep mediation and effect modification by age, sex, baseline attention, mental health and household context.

7. Conclusion

The most consistent association between adolescent smartphone exposure and neurocognitive health concerns nighttime use and sleep: greater late-evening engagement is linked to delayed sleep onset, reduced sleep duration and poorer sleep continuity. Associations with attention and cognitive control are supported by prospective and objective observational studies, but causality remains unproven. Memory findings are mixed and depend strongly on exposure type, age and assessment method. A time-, context- and content-sensitive approach to adolescent smartphone behavior is more defensible than treating all smartphone minutes as equivalent or assuming global neurocognitive harm.

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