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ADHD Symptoms and Academic Performance Among Adolescents: The Roles of Executive Dysfunction, Smartphone Distraction, and Academic Procrastination

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ABSTRACT

Objective: This study aimed to examine the direct and indirect relationships between ADHD symptoms and academic performance among Colombian adolescents by testing the roles of executive dysfunction, smartphone distraction, and academic procrastination within an integrated structural model.

Methods and Materials: A cross-sectional correlational study was conducted with 612 adolescents aged 12–18 years who were recruited from public and private secondary schools in Bogotá, Medellín, and Cali, Colombia, through multistage stratified cluster sampling. ADHD symptoms were assessed using the School Version of the ADHD Rating Scale–5, executive dysfunction using the Behavior Rating Inventory of Executive Function–Second Edition Self-Report Form, smartphone distraction using the Smartphone Distraction Scale, and academic procrastination using the Multidimensional Academic Procrastination Scale–15. Academic performance was obtained from official school records and standardized within school and grade level. Data were analyzed using confirmatory factor analysis, Pearson correlations, and structural equation modeling with cluster-robust standard errors. Indirect effects were examined using 5,000 bias-corrected bootstrap samples.

Findings: ADHD symptoms significantly predicted executive dysfunction, smartphone distraction, academic procrastination, and lower academic performance. Executive dysfunction significantly predicted greater smartphone distraction, greater academic procrastination, and poorer academic performance. Smartphone distraction significantly predicted procrastination and lower academic performance, while academic procrastination was the strongest immediate negative predictor of performance. The total indirect effect of ADHD symptoms on academic performance was significant, $\beta = -.272$, $p < .001$, and the total effect was $\beta = -.402$, $p < .001$. The model explained 39% of the variance in academic performance.

Conclusion: ADHD symptoms were associated with poorer academic performance primarily through executive dysfunction, smartphone distraction, and academic procrastination, indicating that cognitive self-regulation, digital-attention management, and timely task initiation are important targets for school-based and clinical interventions.

Keywords: *ADHD symptoms; academic performance; executive dysfunction; smartphone distraction; academic procrastination; adolescents; Colombia*

1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental condition characterized by developmentally inappropriate and persistent patterns of inattention, hyperactivity, and impulsivity that interfere with functioning across educational, social, and personal contexts. Although ADHD is commonly identified during childhood, its symptoms frequently persist into adolescence and adulthood, where they may become less visibly disruptive but continue to affect self-regulation, decision-making, learning, and goal-directed behavior. Delayed diagnosis may allow academic, emotional, and interpersonal difficulties to accumulate over time, particularly when inattentive symptoms are interpreted as laziness, low motivation, or poor discipline rather than manifestations of a neurodevelopmental condition (Chauhan et al., 2025). The clinical expression of ADHD is also heterogeneous and may differ according to developmental stage, symptom presentation, co-occurring conditions, and environmental demands, making it necessary to examine the mechanisms through which ADHD symptoms affect functioning rather than treating the disorder as a uniform category (Gálvez-Contreras et al., 2022). Evidence that ADHD may co-occur with neurodevelopmental and genetic conditions further highlights its etiological and clinical complexity (Zamboni et al., 2025). Contemporary approaches therefore increasingly conceptualize ADHD symptoms dimensionally, recognizing that meaningful difficulties in attention, inhibition, planning, and self-management may exist across the adolescent population, including among students who do not meet the full criteria for a formal diagnosis.

Adolescence represents a particularly important developmental period for investigating the educational consequences of ADHD symptoms. During secondary education, students are expected to manage increasingly complex assignments, organize multiple deadlines, sustain attention during prolonged instruction, regulate technology use, plan examination preparation, and work independently with reduced external supervision. These demands coincide with ongoing development of prefrontal systems responsible for executive control and self-regulation. Adolescents with elevated ADHD symptoms may therefore experience a widening gap between environmental expectations and their ability to manage academic responsibilities. Decision-making difficulties associated with ADHD, including heightened sensitivity to immediate rewards, reduced consideration of delayed consequences, and inconsistent allocation of attention, can undermine choices related to studying, homework completion, and technology use (Chachar & Shaikh, 2024). Motivation is also relevant because students with ADHD may respond less consistently to distant academic rewards and may rely more strongly on immediate stimulation, personal interest, or external structure to initiate and sustain effort (Morsink et al., 2021). When school tasks are repetitive, difficult, delayed in their rewards, or weakly connected to students' immediate interests, adolescents with ADHD symptoms may be especially vulnerable to disengagement and task avoidance.

Academic performance is among the most consequential areas affected by ADHD symptoms. Poorer grades during adolescence may limit access to advanced education, reduce occupational opportunities, and contribute to negative beliefs about competence and future success. Long-term evidence indicates that individuals with ADHD often experience difficulties in schooling and employment, although supportive educational environments, individualized strategies, and effective self-management can improve outcomes (Varrasi et al., 2022). Academic achievement is not determined solely by intellectual ability; it also depends on attention control, working memory, planning, motivation, emotional regulation, persistence, and the capacity to delay immediate gratification. Consequently, adolescents with adequate cognitive ability may still underperform when they are unable to organize schoolwork, remain focused, resist distraction, or complete tasks on time. Research on giftedness similarly suggests that high potential may fail to develop when executive, motivational, emotional, or environmental barriers interfere with sustained learning and performance (Pergantis, 2024). Understanding why ADHD symptoms predict lower academic performance therefore requires consideration of intermediate psychological and behavioral processes that translate attentional and regulatory difficulties into observable educational outcomes.

Executive dysfunction is one of the most theoretically relevant mechanisms connecting ADHD symptoms with academic performance. Executive functions refer to higher-order cognitive and self-regulatory processes that enable individuals to inhibit dominant responses, hold and manipulate information in working memory, shift flexibly between tasks, regulate emotions, plan behavior, monitor progress, and pursue delayed goals. A distinction is often made between "cool" executive functions, which operate in relatively abstract and emotionally neutral situations, and

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"hot" executive functions, which are activated in motivationally or emotionally salient contexts (Košíková et al., 2024). Both forms may be disrupted in ADHD. Difficulties in cool executive functions can impair note-taking, comprehension, task sequencing, and examination preparation, whereas difficulties in hot executive functions can increase impulsive choices, emotional reactivity, and preference for immediately rewarding activities over delayed academic benefits.

Attention control deficits are especially central to ADHD because they restrict the ability to select task-relevant information, maintain concentration, and suppress competing stimuli (Luo et al., 2021). Working-memory limitations may make it difficult for students to retain instructions, integrate information across a lesson, monitor multistep assignments, or resume a task after interruption. Problems in inhibition can lead to premature responses, frequent shifts between activities, and difficulty resisting environmental distractions. Planning and organizational deficits may result in forgotten materials, underestimated task demands, missed deadlines, and inefficient study schedules. Studies of children with listening difficulties have likewise demonstrated that executive-functioning skills are closely related to the ability to process instructions and function effectively in school contexts (McGrath et al., 2023). Thus, executive dysfunction may affect academic performance directly by reducing the efficiency and consistency with which students perform learning activities.

Executive dysfunction may also function as an explanatory bridge between ADHD symptoms and other psychosocial outcomes. In clinical adolescent populations, executive functions have been shown to mediate associations between ADHD symptoms and anxiety, indicating that self-regulatory deficits may transmit the effects of ADHD symptoms into broader areas of functioning (Haugan et al., 2022). Cognitive mechanisms such as impaired executive control, reward processing, and emotion regulation have also been implicated in the relationship between ADHD and depressive disorders (Mayer et al., 2021). Emotion-regulation difficulties are particularly important because ADHD-related executive impairments may make it harder for adolescents to manage frustration, boredom, academic failure, and negative feedback (Malik & Namgyal, 2024). Similar mediating roles of real-world executive functions have been reported in research involving other neurodevelopmental conditions, supporting the broader proposition that executive functioning translates underlying neurodevelopmental characteristics into everyday impairment (Chien et al., 2023). These findings suggest that executive dysfunction may not merely accompany ADHD symptoms but may represent a central mechanism through which those symptoms affect academic behavior and achievement.

The importance of executive functioning is further supported by intervention research. Systematic reviews indicate that executive-function stimulation methods for individuals with ADHD include cognitive training, behavioral interventions, neurofeedback, physical activity, digital training platforms, and combined approaches (Ramos-Galarza et al., 2024). Artificial cognitive systems have also been incorporated into executive-function stimulation and rehabilitation programs, offering adaptive exercises, immediate feedback, individualized difficulty levels, and opportunities for repeated practice (Robledo-Castro et al., 2022). Emerging assessment approaches have applied artificial intelligence and virtual reality to identify distinct cognitive profiles associated with ADHD presentations, potentially allowing more precise characterization of attentional and executive deficits (Yılmaz et al., 2025). Pharmacological research similarly suggests that improvements in executive functioning and learning-related problems may accompany effective ADHD treatment (Wilens et al., 2026). These developments reinforce the relevance of executive dysfunction to academic functioning while also indicating that it may be modifiable.

Physical activity represents another avenue through which executive functioning and cognitive performance may be strengthened. Meta-analytic evidence has shown that physical activity can improve executive functions in children and adolescents with ADHD (Song et al., 2023). Broader reviews of physical activity, sedentary behavior, screen time, and cognition also indicate that movement and digital behavior may interact in shaping cognitive outcomes during development (Dergaa et al., 2026). Digital applications have accordingly been proposed to encourage physical activity and support ADHD treatment, including among racial and ethnic minority populations that may face barriers to conventional services (Doulou et al., 2023). Gamified mobile applications have also been explored as early interventions for students with ADHD, demonstrating the potential for technology to support engagement when it is structured and therapeutically designed (Kakoura et al., 2024). Technology is therefore not inherently harmful; its effects depend on the type, purpose, intensity, and regulation of use.

Nevertheless, smartphones and other digital technologies create a highly salient source of distraction for adolescents. Smartphones provide continuous access to social media, messaging, games, videos, and personalized notifications, all of which compete with academic tasks for limited attentional resources. Reviews of digital technology have raised concerns regarding its potential negative effects on cognition, including sustained attention, working memory, cognitive control, and learning efficiency (Žnidarič et al., 2026). Excessive smartphone use has also been associated with a range of physical and psychological problems among adolescents and young adults, including sleep disruption, reduced well-being, and problematic patterns of dependence (Wacks & Weinstein, 2021). These consequences may be especially relevant to students with ADHD symptoms because digital platforms provide immediate, variable, and emotionally salient rewards that may be more compelling than delayed academic outcomes.

Research during the COVID-19 pandemic showed that children and adolescents with ADHD experienced substantial changes in digital media use, with increased exposure potentially intensifying attention, behavioral, and emotional difficulties (Shuai et al., 2021). Even outside pandemic conditions, adolescents with ADHD may display distinctive patterns of sensory processing and smartphone use, suggesting that their engagement with digital devices may differ qualitatively from that of typically developing peers (Fabio & Suriano, 2024). Learning disabilities may further shape digital behavior in adolescents with ADHD, indicating that technology use is influenced by the interaction of neurodevelopmental and educational vulnerabilities (Kocabaş et al., 2025). At the same time, not every form of digital engagement produces measurable academic harm. For example, research involving children and adolescents with ADHD found that video game addiction was not necessarily associated with poorer educational outcomes in all contexts (Blasco-Fontecilla et al., 2023). Such findings underscore the need to distinguish general screen time or device use from smartphone distraction, which refers more specifically to interruptions of goal-directed attention, habitual checking, online vigilance, multitasking, and difficulty disengaging from device-related cues.

Smartphone distraction may be influenced by executive-functioning difficulties. Adolescents who struggle with inhibition may be less able to resist checking notifications, while those with weak working memory may lose track of academic goals after device-related interruptions. Difficulties in emotional regulation may also encourage smartphone use as a means of escaping boredom, frustration, anxiety, or uncertainty. Research has linked impulsivity, intolerance of uncertainty, and smartphone-management styles with smartphone addiction through warm executive functions, suggesting that emotionally and motivationally charged executive processes contribute to maladaptive smartphone behavior (Asheri et al., 2024). Consequently, executive dysfunction may increase smartphone distraction, which may then consume study time, fragment concentration, and interfere with the completion of academic responsibilities.

Academic procrastination constitutes another likely mechanism through which ADHD symptoms and smartphone distraction influence academic performance. Academic procrastination involves the voluntary and unnecessary delay of intended school-related activities despite awareness that postponement may lead to negative consequences. It is not simply poor time management; it reflects difficulties in task initiation, emotion regulation, motivation, self-control, and the prioritization of long-term goals. Students may procrastinate because assignments are experienced as boring, aversive, difficult, overwhelming, or insufficiently rewarding. These characteristics overlap closely with the motivational and executive difficulties associated with ADHD. Adolescents with elevated ADHD symptoms may underestimate the time required for assignments, forget deadlines, become distracted during task initiation, or repeatedly choose immediately rewarding alternatives. Early developmental evidence indicates that executive dysfunction, delay aversion, and time-perception deficits are associated with ADHD symptoms and academic performance, supporting the idea that distorted time management and preference for immediate rewards may contribute to educational difficulties from an early age (Zheng et al., 2022).

Smartphone distraction may amplify procrastination by providing an easily accessible alternative whenever academic discomfort arises. A student who intends to study may respond to one notification, begin scrolling through social media, shift to another application, and lose substantial time before returning to the original task. Repeated interruptions can increase the perceived effort of schoolwork and weaken task continuity. Problematic internet use has been associated with poorer academic achievement, with mediators including reduced study time, sleep problems, diminished self-regulation, and psychological distress (Gül et al., 2022). Sleep is particularly relevant because ADHD symptoms, neuropsychological functioning, and homework problems may interact with inadequate or disrupted sleep (Smets et al., 2025). Smartphone use during the evening may delay bedtime, reduce sleep quality, and worsen next-day attention, thereby creating a cycle in which tired students become more distractible and more likely to postpone demanding tasks.

Broader developmental and contextual factors should also be considered. Neurodevelopmental outcomes, including cognitive and behavioral vulnerabilities, may be influenced by prenatal and biological conditions such as maternal obesity, although such influences are distal and interact with numerous environmental and individual factors (Gkintoni et al., 2025). Within the school context, the impact of ADHD symptoms may vary according to instructional structure, teacher support, family monitoring, socioeconomic resources, and access to assessment or treatment. This contextual variability is particularly important in culturally and economically diverse settings. Much of the available literature on ADHD, executive functioning, problematic technology use, and academic achievement has been conducted in North American, European, or Asian samples. Comparatively less integrated evidence is available from Latin American adolescents, even though cultural expectations, educational systems, access to mental health services, and patterns of digital technology use may differ across regions.

Colombia provides a relevant setting for investigating these relationships. Adolescents in Colombian secondary schools are increasingly exposed to smartphones and online learning resources while simultaneously navigating educational inequality, varying levels of school support, and uneven access to specialized mental health services. In this context, identifying pathways that connect ADHD symptoms with academic performance may have practical value for schools, families, psychologists, and policymakers. Rather than focusing only on diagnostic status, a dimensional model can identify modifiable mechanisms among a broad range of students. Executive dysfunction may be addressed through organizational training, cognitive support, environmental structure, and clinical treatment; smartphone distraction may be reduced through notification management, device-use planning, and classroom policies; and academic procrastination may be targeted through task breakdown, implementation intentions, time-management training, and motivational interventions.

Despite growing research on each of these variables, important gaps remain. Previous studies have established associations between ADHD and executive dysfunction, between problematic digital behavior and academic outcomes, and between self-regulation problems and procrastination. However, these processes are often examined separately. Less is known about whether ADHD symptoms affect academic performance through multiple simultaneous and sequential pathways involving executive dysfunction, smartphone distraction, and academic procrastination. An integrated model is necessary because these mechanisms may reinforce one another. ADHD symptoms may contribute to executive dysfunction; executive dysfunction may increase vulnerability to smartphone distraction and procrastination; smartphone distraction may further intensify procrastination; and these processes may jointly undermine academic performance. Testing both direct and indirect relationships can clarify whether the association between ADHD symptoms and achievement remains significant after these mechanisms are considered and can identify which pathway accounts for the largest proportion of academic difficulty.

Accordingly, the aim of the present study was to examine the direct and indirect relationships between ADHD symptoms and academic performance among Colombian adolescents by testing the roles of executive dysfunction, smartphone distraction, and academic procrastination within an integrated structural model.

2. Methods and Materials

2.1. *Study Design and Participants*

This study employed a quantitative, cross-sectional, correlational design to examine the relationship between attention-deficit/hyperactivity disorder symptoms and academic performance among Colombian adolescents and to determine the roles of executive dysfunction, smartphone distraction, and academic procrastination in this relationship. The study population consisted of adolescents enrolled in public and private secondary schools in Bogotá, Medellín, and Cali, Colombia, during the 2025–2026 academic year. A total of 612 adolescents were recruited from 24 secondary schools, with eight schools selected from each city. Participants were between 12 and 18 years of age and were enrolled in grades 7 through 11. A multistage stratified cluster-sampling procedure was used to obtain a sample reflecting variation in geographical location, school sector, grade level, and socioeconomic background. In the first stage, the three cities were selected because they represent major urban educational contexts in Colombia. In the second stage, schools were stratified as public or private, and an equal number of schools from each sector was randomly selected within each city. In the third stage, classrooms were randomly selected from the eligible grade levels, and all students in the selected classrooms were invited to participate. Adolescents were eligible when they were enrolled as regular students, were between 12 and 18 years of age, had used a smartphone for at least six months, possessed sufficient Spanish-language proficiency to understand the questionnaires, and provided written assent accompanied by written informed consent from a parent or legal guardian. Students were excluded when school records indicated a diagnosed intellectual disability, a severe neurological condition, an uncorrected sensory impairment, or another condition that would prevent independent completion of the measures. Questionnaires with more than 10% missing responses or clearly inconsistent response patterns were excluded before the final analysis. Participation was voluntary, and students were informed that they could discontinue their involvement at any time without academic or personal consequences. Data were collected during regular school hours in quiet classrooms under the supervision of trained research assistants who were not employed by the participating schools. Each participant received a coded identification number, allowing questionnaire data, teacher ratings, and academic records to be linked without recording students' names in the analytical dataset.

2.2. Measures

A researcher-developed sociodemographic and educational questionnaire was used to collect information concerning age, sex, grade level, city of residence, type of school, parental educational attainment, perceived family socioeconomic status, average daily smartphone use, age at first smartphone ownership, nightly sleep duration, previous ADHD diagnosis, current psychological or pharmacological treatment, and access to academic support services. These variables were collected to describe the sample and identify potential covariates that could influence academic performance or the psychological variables examined in the study. The questionnaire was reviewed by specialists in adolescent psychology, educational psychology, and psychological measurement to ensure that its content was understandable and culturally appropriate for Colombian secondary-school students. It was pilot-tested with a group of adolescents who were not included in the principal sample, and minor wording modifications were made to improve clarity.

ADHD symptoms were assessed using the School Version of the ADHD Rating Scale–5. The scale contains 18 items corresponding to the core behavioral symptoms of ADHD and produces separate scores for inattention and hyperactivity–impulsivity, as well as a total ADHD symptom score. Nine items assess inattentive behaviors, such as difficulty sustaining attention, failure to complete schoolwork, forgetfulness, disorganization, and avoidance of tasks requiring prolonged mental effort, whereas nine items assess hyperactive and impulsive behaviors, such as restlessness, excessive talking, difficulty waiting, interrupting others, and acting without adequate consideration of consequences. Each item is scored on a four-point scale ranging from 0, indicating that the behavior never or rarely occurs, to 3, indicating that it occurs very often. Total scores range from 0 to 54, with higher scores representing greater ADHD symptom severity. The school version was completed by a teacher who had taught the student regularly for at least three months and was sufficiently familiar with the student's classroom behavior. The instrument was used to assess symptom severity rather than establish a clinical ADHD diagnosis. The ADHD Rating Scale–5 includes nine indicators of inattention and nine indicators of hyperactivity–impulsivity.

Executive dysfunction was measured using the Spanish-language Self-Report Form of the Behavior Rating Inventory of Executive Function, Second Edition. This 55-item instrument assesses adolescents' perceptions of executive functioning and self-regulatory difficulties in everyday environments. Its clinical scales evaluate inhibition, self-monitoring, cognitive flexibility, emotional control, task completion, working memory, and planning and organization. Responses are provided using a three-point format indicating whether each behavior occurs never, sometimes, or often. Scale scores are combined to produce broader indices of behavioral regulation, emotional regulation, and cognitive regulation, together with a Global Executive Composite score. Higher scores indicate greater difficulty regulating behavior, emotions, attention, working memory, planning, task initiation, and goal-directed activity. The Global Executive Composite was used as the principal indicator of executive dysfunction in the hypothesized structural model, while the individual scale scores were retained for supplementary analyses. The response-consistency, negativity, and infrequency indicators were examined before calculating the composite score, and

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protocols demonstrating invalid or highly inconsistent response patterns were excluded. The BRIEF–2 Self-Report Form is intended for adolescents between 11 and 18 years of age and contains 55 items distributed across seven clinical scales.

Smartphone distraction was evaluated using the Smartphone Distraction Scale. The scale consists of 16 items designed to assess the degree to which smartphone-related thoughts, notifications, habits, and activities interrupt sustained attention and goal-directed behavior. The instrument covers attention impulsiveness, online vigilance, smartphone-related multitasking, and the use of smartphones for emotion regulation. Participants rated each statement on a five-point Likert scale ranging from strong disagreement to strong agreement. A total score was calculated by summing the responses after reverse-scoring negatively worded items where applicable, with higher scores indicating a stronger tendency to become distracted by smartphones during academic activities and everyday tasks. Before the principal data collection, the Spanish wording of the instrument was reviewed by bilingual psychologists and educational specialists familiar with Colombian Spanish. Cognitive interviews and pilot administration were conducted to verify that the items were understandable to adolescents and that references to online activities, notifications, social networking platforms, and smartphone use were culturally appropriate. The Smartphone Distraction Scale comprises 16 items representing four related dimensions: attention impulsiveness, online vigilance, multitasking, and emotion regulation.

Academic procrastination was measured using the Spanish version of the Multidimensional Academic Procrastination Scale–15. This instrument assesses the repeated and unnecessary postponement of academic responsibilities, including beginning assignments, studying for examinations, completing homework, organizing school activities, and meeting deadlines. The 15 statements were answered on a five-point Likert scale ranging from strongly disagree to strongly agree. After reverse-scoring the relevant items, responses were summed to produce a total academic procrastination score, with higher scores indicating more frequent postponement, poorer academic time management, greater difficulty initiating school tasks, and a stronger tendency to delay academic work despite anticipating negative consequences. The total score was used in the principal analyses because the study focused on adolescents' general tendency to procrastinate across academic tasks. The Spanish item wording was reviewed for its suitability for Colombian secondary education, and references primarily applicable to university students were replaced with equivalent secondary-school activities without changing the conceptual meaning of the items. The measure was pilot-tested before the principal study, and its factor structure and internal consistency were re-examined in the final sample. A Spanish version of the measure has demonstrated applicability to the assessment of academic procrastination in children and adolescents.

Academic performance was determined objectively from official school records rather than from students' self-reported grades. The academic performance indicator was calculated using each participant's final grades in Spanish language, mathematics, natural sciences, social sciences, and English during the most recently completed academic term. The grades were averaged to create a general academic performance score. Because grading practices and numerical scales could differ among participating schools, the average grades were standardized within each school and grade level before being combined across the three cities. Standardized scores above zero indicated performance above the mean of the student's school and grade, whereas scores below zero indicated performance below the corresponding mean. This procedure reduced the influence of differences in grading policies, course difficulty, and institutional assessment practices. School administrators provided the academic records only after parental authorization had been obtained, and the records were linked to questionnaire responses through anonymous identification codes.

The questionnaires were administered in Spanish in a fixed sequence, beginning with the sociodemographic questionnaire and followed by the measures of executive dysfunction, smartphone distraction, and academic procrastination. The complete student assessment required approximately 35 to 45 minutes. Teachers completed the ADHD symptom ratings independently within one week of the student assessment. To reduce social-desirability and evaluation concerns, teachers were informed that their ratings would not be shared with students, parents, or school administrators and would not be used for diagnostic or disciplinary purposes. Students were seated sufficiently far apart to protect the privacy of their responses and were instructed not to discuss their answers with classmates. Research assistants checked the questionnaires immediately after completion to identify unintentionally omitted items, although participants were not pressured to answer questions they preferred to leave unanswered.

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2.3. Data Analysis

Data analysis was conducted using statistical software suitable for descriptive analysis, confirmatory factor analysis, and structural equation modeling. Before hypothesis testing, the dataset was examined for entry errors, duplicate records, response-pattern irregularities, univariate and multivariate outliers, and missing observations. The distributions of continuous variables were evaluated using skewness, kurtosis, histograms, and normal probability plots. Mahalanobis distance was used to identify potentially influential multivariate cases, and sensitivity analyses were conducted with and without highly influential observations. Missing-data patterns were examined to determine whether missingness was systematic. When the amount of missing information was limited and compatible with a missing-at-random assumption, full-information maximum-likelihood estimation was used so that participants with partially missing responses could be retained without applying single-value imputation. Questionnaires exceeding the predetermined missing-response threshold were excluded before model estimation.

Descriptive statistics, including means, standard deviations, observed ranges, skewness, and kurtosis, were calculated for ADHD symptoms, executive dysfunction, smartphone distraction, academic procrastination, and academic performance. Frequencies and percentages were calculated for categorical demographic variables. Internal consistency was examined using Cronbach's alpha and McDonald's omega, with coefficients of .70 or higher considered adequate for research purposes. Confirmatory factor analyses were conducted to evaluate the measurement structure of the multi-item instruments in the Colombian adolescent sample. Models were estimated using robust maximum-likelihood estimation to reduce the influence of non-normality. Measurement-model adequacy was evaluated using the chi-square statistic, comparative fit index, Tucker–Lewis index, root mean square error of approximation with its 90% confidence interval, and standardized root mean square residual. Standardized factor loadings, residual variances, composite reliability, and average variance extracted were also examined. When theoretically justified, correlated residuals were permitted only between items with closely related wording or content, and model modifications were not introduced solely to improve statistical fit.

Pearson correlation coefficients were calculated to examine the bivariate relationships among the principal variables. Independent-samples tests and analyses of variance were used in preliminary analyses to determine whether the study variables differed according to sex, grade level, city, or school sector. Associations involving ordinal or non-normally distributed covariates were examined using appropriate nonparametric procedures. Multicollinearity was evaluated through tolerance values, variance inflation factors, and correlations among the predictors. Age, sex, grade level, perceived socioeconomic status, school sector, average nightly sleep duration, daily smartphone-use duration, and previous ADHD diagnosis were considered potential covariates. Covariates were retained in the final model when they demonstrated a theoretically plausible or statistically meaningful association with one or more endogenous variables.

Structural equation modeling was used to test the hypothesized relationships among ADHD symptoms, executive dysfunction, smartphone distraction, academic procrastination, and academic performance. ADHD symptoms were specified as the principal predictor, academic performance was specified as the final outcome, and executive dysfunction, smartphone distraction, and academic procrastination were specified as explanatory variables through which ADHD symptoms could be associated with academic performance. The model included a direct path from ADHD symptoms to academic performance and indirect paths through each of the three explanatory variables. It also included theoretically ordered pathways in which greater ADHD symptoms predicted greater executive dysfunction, greater executive dysfunction predicted increased susceptibility to smartphone distraction and academic procrastination, and smartphone distraction predicted greater academic procrastination. This specification allowed the analysis to estimate separate indirect effects through executive dysfunction, smartphone distraction, and academic procrastination, as well as sequential indirect effects linking ADHD symptoms to poorer academic performance through combinations of these variables.

Indirect effects were tested using bias-corrected bootstrap confidence intervals based on 5,000 resamples. An indirect effect was considered statistically significant when its 95% confidence interval did not include zero. Standardized direct, indirect, and total effects were reported to facilitate comparison across pathways. The proportion of variance explained in executive dysfunction, smartphone distraction, academic procrastination, and academic performance was calculated using squared multiple correlations. Because

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students were nested within schools, cluster-robust standard errors were used to account for the non-independence of observations originating from the same institution. Differences between public and private schools and among Bogotá, Medellín, and Cali were additionally examined through sensitivity analyses. Statistical significance was evaluated at a two-sided alpha level of .05, while effect sizes and confidence intervals were emphasized when interpreting the magnitude and precision of the findings.

3. Findings and Results

The final analytical sample comprised 612 adolescents enrolled in secondary schools in Bogotá, Medellín, and Cali, Colombia. The participants ranged in age from 12 to 18 years, with a mean age of 15.14 years (SD = 1.63). Of the participants, 319 were female (52.1%), 287 were male (46.9%), and 6 reported another gender identity or preferred not to report their gender (1.0%). The distribution across grade levels was relatively balanced: 116 participants were enrolled in Grade 7 (19.0%), 123 in Grade 8 (20.1%), 126 in Grade 9 (20.6%), 125 in Grade 10 (20.4%), and 122 in Grade 11 (19.9%). In accordance with the sampling design, 204 participants were recruited from each of Bogotá, Medellín, and Cali, representing 33.3% of the sample per city. Moreover, 306 adolescents attended public schools and 306 attended private schools. Regarding perceived family socioeconomic status, 196 participants described their socioeconomic status as low (32.0%), 326 as middle (53.3%), and 90 as high (14.7%). The participants reported using their smartphones for an average of 5.37 hours per day (SD = 2.18), while their mean nightly sleep duration was 7.21 hours (SD = 1.08). Fifty-five adolescents had previously received an ADHD diagnosis (9.0%), 24 were receiving pharmacological treatment for ADHD or another psychological condition at the time of data collection (3.9%), and 71 were receiving formal academic support services at school (11.6%). Preliminary comparisons indicated that adolescents with a previous ADHD diagnosis had significantly higher teacher-rated ADHD symptoms and executive dysfunction scores than those without a diagnosis. Nevertheless, both diagnosed and undiagnosed participants were retained because the study examined ADHD symptoms dimensionally across the general adolescent population rather than restricting the analysis to clinically diagnosed cases.

Table 1

Descriptive Statistics and Correlations Among the Principal Study Variables

Variable	M	SD	Minimum	Maximum	Skewness	Kurtosis	1	2	3	4	5
1. ADHD symptoms	19.84	8.72	1.00	49.00	0.53	-0.21	—				
2. Executive dysfunction	98.67	18.31	58.00	153.00	0.31	-0.34	.62***	—			
3. Smartphone distraction	48.96	11.27	18.00	77.00	-0.11	-0.55	.39***	.45***	—		
4. Academic procrastination	43.52	10.94	16.00	73.00	0.06	-0.47	.48***	.57***	.49***	—	
5. Academic performance	3.76	0.51	2.11	4.91	-0.28	-0.19	-.41***	-.46***			

As presented in Table 1, the distributions of all principal variables were within acceptable limits for subsequent parametric and structural analyses. The absolute skewness values ranged from 0.06 to 0.53, while the absolute kurtosis values ranged from 0.19 to 0.55, indicating no substantial univariate departure from normality. The mean ADHD symptom score was 19.84, suggesting considerable variability in attention, hyperactivity, and impulsivity symptoms across the nonclinical school-based sample. The mean executive dysfunction score was 98.67, while the mean smartphone distraction and academic procrastination scores were 48.96 and 43.52, respectively. The mean academic grade was 3.76 on the Colombian 0-to-5 grading scale. ADHD symptoms demonstrated a strong positive correlation with executive dysfunction, $r = .62$, $p < .001$, indicating that adolescents rated as having more pronounced ADHD symptoms also reported substantially greater difficulty with behavioral regulation, emotional regulation, working memory, planning, organization, and task completion. ADHD symptoms were also positively correlated with smartphone distraction, $r = .39$, $p < .001$, and academic procrastination, $r = .48$, $p < .001$. Thus, greater ADHD symptom severity was associated with a stronger tendency to become distracted by smartphone-related cues and to postpone school-related responsibilities. Executive dysfunction was positively associated with smartphone distraction, $r = .45$, $p < .001$, and academic procrastination, $r = .57$, $p < .001$. Smartphone distraction was likewise positively associated with academic procrastination, $r = .49$, $p < .001$. Academic performance was negatively correlated with ADHD symptoms, $r = -.41$, $p < .001$, executive dysfunction, $r = -.46$, $p < .001$, smartphone distraction, r = -

.31, $p < .001$, and academic procrastination, $r = -.52$, $p < .001$. The largest bivariate association with academic performance was observed for academic procrastination, indicating that adolescents who more frequently postponed studying, homework, examination preparation, and other academic responsibilities tended to obtain lower grades. None of the correlations among the predictor variables exceeded .70, suggesting that the constructs were meaningfully related but sufficiently distinct and that severe multicollinearity was unlikely.

Table 2

Reliability, Convergent Validity, and Confirmatory Factor Analysis Results for the Measurement Model

Construct	Number of indicators	Retained factor structure	Standardized loading range	Cronbach's α	McDonald's ω	Composite reliability	Average variance extracted
ADHD symptoms	18 items	Two correlated factors: inattention and hyperactivity–impulsivity	.61–.84	.91	.92	.92	.51
Executive dysfunction	7 clinical-scale indicators	Three first-order domains with a higher-order executive dysfunction factor	.64–.88	.94	.95	.94	.58
Smartphone distraction	16 items	Four correlated factors: attention impulsiveness, online vigilance, multitasking, and emotion regulation	.58–.83	.89	.90	.90	.53
Academic procrastination	15 items	One general academic procrastination factor	.60–.86	.92	.92	.92	.55
Academic performance	5 subject grades	One academic achievement factor	.69–.88	.88	.89	.89	.

Table 2 presents the reliability and measurement-model findings for ADHD symptoms, executive dysfunction, smartphone distraction, academic procrastination, and academic performance. The hypothesized measurement model provided a good fit to the observed data, $\chi^2(421) = 789.46$, $p < .001$, CFI = .956, TLI = .950, RMSEA = .038, 90% CI [.034, .042], and SRMR = .041. Although the chi-square statistic was significant, this result was expected because chi-square tests are highly sensitive to large sample sizes. The incremental and residual-based fit indices consistently supported the adequacy of the measurement model. The standardized factor loadings were statistically significant and ranged from .58 to .88 across the constructs, indicating that the selected indicators adequately represented their intended latent variables. The ADHD symptom items loaded between .61 and .84 on the inattention and hyperactivity–impulsivity factors. The seven executive-functioning indicators loaded between .64 and .88 on the behavioral, emotional, and cognitive regulation domains, which in turn loaded significantly on the higher-order executive dysfunction factor. The smartphone distraction items had standardized loadings ranging from .58 to .83 across attention impulsiveness, online vigilance, multitasking, and emotion-regulation dimensions. The academic procrastination items loaded between .60 and .86 on the general procrastination factor, while the five subject grades loaded between .69 and .88 on the academic performance factor. All Cronbach's alpha and McDonald's omega coefficients exceeded .88, demonstrating strong internal consistency. Composite reliability values ranged from .89 to .94 and therefore exceeded the recommended minimum criterion of .70. Average variance extracted values ranged from .51 to .62, indicating that each latent construct accounted for more than half of the variance in its indicators. These results supported the reliability, convergent validity, and factorial validity of the measures and justified their inclusion in the structural model. The distinction among the constructs was additionally supported by the moderate correlations observed in Table 1 and by the finding that a model treating ADHD symptoms, executive dysfunction, smartphone distraction, and academic procrastination as separate constructs fitted the data substantially better than models combining them into fewer factors.

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Table 3

Standardized Direct Effects in the Structural Model Predicting Academic Performance

Structural path	Standardized estimate, β	SE	z	p	95% CI
ADHD symptoms → Executive dysfunction	.62	.035	17.71	< .001	[.55, .69]
ADHD symptoms → Smartphone distraction	.18	.041	4.39	< .001	[.10, .26]
Executive dysfunction → Smartphone distraction	.34	.044	7.73	< .001	[.25, .43]
ADHD symptoms → Academic procrastination	.12	.040	3.00	.003	[.04, .20]
Executive dysfunction → Academic procrastination	.31	.045	6.89	< .001	[.22, .40]
Smartphone distraction → Academic procrastination	.28	.039	7.18	< .001	[.20, .36]
ADHD symptoms → Academic performance	-.13	.043	-3.02	.003	[-.21, -.05]
Executive dysfunction → Academic performance	-.17	.046	-3.70	< .001	[-.26, -.08]
Smartphone distraction → Academic performance	-.08	.035	-2.29	.022	[-.15, -.01]
Academic procrastination → Academic performance	-.32	.042	-7.62	< .001	[-.40, -.24]

The structural model presented in Table 3 demonstrated an acceptable-to-good fit to the data, $\chi^2(436) = 842.16$, $p < .001$, CFI = .950, TLI = .944, RMSEA = .039, 90% CI [.035, .043], and SRMR = .043. ADHD symptoms had a strong positive association with executive dysfunction, $\beta = .62$, $p < .001$, indicating that a one-standard-deviation increase in ADHD symptom severity was associated with a .62-standard-deviation increase in executive-functioning difficulties. ADHD symptoms also had a positive direct association with smartphone distraction, $\beta = .18$, $p < .001$, even after executive dysfunction, demographic characteristics, daily smartphone-use duration, sleep duration, and previous ADHD diagnosis were controlled. Executive dysfunction was positively associated with smartphone distraction, $\beta = .34$, $p < .001$, suggesting that adolescents who experienced greater difficulty inhibiting responses, maintaining information in working memory, planning activities, monitoring their behavior, and regulating emotions were more likely to be distracted by smartphone notifications, online monitoring, multitasking, and habitual device checking. ADHD symptoms had a smaller but significant direct association with academic procrastination, $\beta = .12$, $p = .003$. Executive dysfunction, $\beta = .31$, $p < .001$, and smartphone distraction, $\beta = .28$, $p < .001$, also positively predicted academic procrastination. These results indicated that procrastination was associated not only with ADHD symptom severity itself but also with the executive-regulation and digital-attention difficulties accompanying those symptoms. All four principal predictors had significant negative direct associations with academic performance. ADHD symptoms retained a significant direct effect on academic performance, $\beta = -.13$, $p = .003$, after the three explanatory variables and covariates had been included. Executive dysfunction was negatively associated with academic performance, $\beta = -.17$, $p < .001$, and smartphone distraction had a smaller but statistically significant negative association, $\beta = -.08$, $p = .022$. Academic procrastination was the strongest immediate negative predictor of academic performance, $\beta = -.32$, $p < .001$. The model explained 38% of the variance in executive dysfunction, 29% of the variance in smartphone distraction, 47% of the variance in academic procrastination, and 39% of the variance in academic performance. Therefore, the combined effects of ADHD symptoms, executive dysfunction, smartphone distraction, academic procrastination, and the included covariates accounted for a substantial proportion of individual differences in adolescents' school grades.

Table 4

Bootstrapped Indirect and Total Effects of ADHD Symptoms on Academic Performance

Effect pathway	Standardized effect	Bootstrap SE	95% bootstrap CI	p
ADHD symptoms → Executive dysfunction → Academic performance	-.105	.021	[-.150, -.068]	< .001
ADHD symptoms → Smartphone distraction → Academic performance	-.014	.007	[-.031, -.004]	.024
ADHD symptoms → Academic procrastination → Academic performance	-.038	.015	[-.071, -.012]	.006
ADHD symptoms → Executive dysfunction → Smartphone distraction → Academic performance	-.017	.006	[-.031, -.008]	.002

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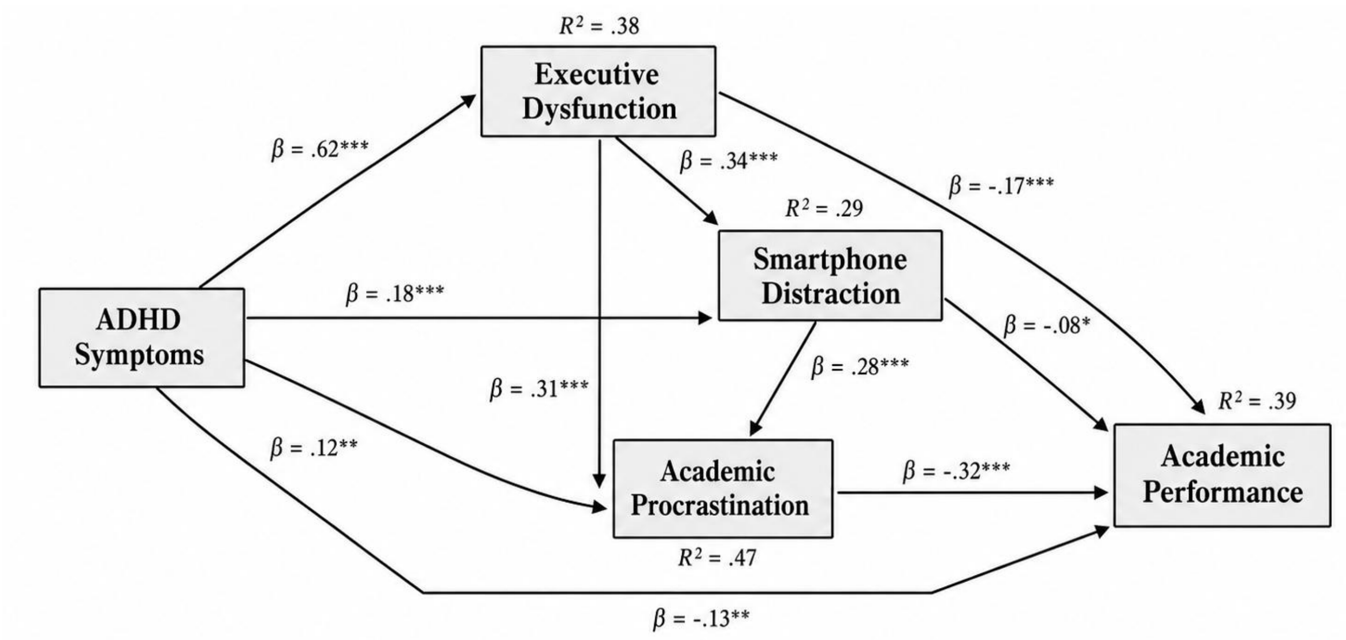
ADHD symptoms → Executive dysfunction → Academic procrastination → Academic performance	-.062	.014	[-.093, -.038]	< .001
ADHD symptoms → Smartphone distraction → Academic procrastination → Academic performance	-.016	.006	[-.031, -.007]	.002
ADHD symptoms → Executive dysfunction → Smartphone distraction → Academic procrastination → Academic performance	-.019	.006	[-.033, -.010]	< .001
Total indirect effect	-.272	.029	[-.331, -.219]	< .001
Direct effect	-.130	.043	[-.214, -.049]	.003
Total effect	-.402	.034	[-.469, -.337]	< .001

Figure 1

Standardized Structural Model of the Associations Among ADHD Symptoms, Executive Dysfunction, Smartphone Distraction, Academic Procrastination, and Academic Performance



As shown in Table 4, ADHD symptoms had a significant total negative effect on academic performance, β = -.402, p < .001. The total indirect effect operating through executive dysfunction, smartphone distraction, and academic procrastination was also significant, β = -.272, p < .001, with a 95% bootstrap confidence interval ranging from -.331 to -.219. Because this interval did not include zero, the collective explanatory effect of the three intervening variables was supported. The largest specific indirect effect occurred through executive dysfunction alone, β = -.105, p < .001, demonstrating that ADHD symptoms were associated with poorer academic performance partly because they were strongly related to deficits in inhibition, working memory, monitoring, planning, organization, emotional control, and task completion. ADHD symptoms also had a significant indirect effect through academic procrastination alone, β = -.038, p = .006, and a smaller indirect effect through smartphone distraction alone, β = -.014, p = .024. The sequential pathway from ADHD symptoms through executive dysfunction and academic procrastination to academic performance was significant, β = -.062, p < .001. This finding indicated that greater ADHD symptoms were associated with greater executive dysfunction, which in turn increased adolescents' tendency to postpone academic responsibilities, ultimately contributing to lower academic performance. The pathway involving executive dysfunction followed by smartphone distraction was also significant, β = -.017, p = .002. In addition, the sequential indirect effect through smartphone distraction and academic procrastination was significant, β = -.016, p = .002, indicating that ADHD symptoms contributed to smartphone-related attentional disruption, which was associated with greater delay in completing schoolwork and consequently poorer grades. The longest sequential pathway, in which

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ADHD symptoms predicted executive dysfunction, executive dysfunction predicted smartphone distraction, smartphone distraction predicted academic procrastination, and procrastination predicted lower academic performance, was statistically significant, $\beta = -.019$, $p < .001$. The direct effect of ADHD symptoms remained significant after all indirect pathways were included, $\beta = -.130$, $p = .003$. Accordingly, executive dysfunction, smartphone distraction, and academic procrastination partially, rather than fully, explained the association between ADHD symptoms and academic performance. Approximately 67.7% of the total association between ADHD symptoms and academic performance was attributable to the combined indirect pathways, while the remaining 32.3% was represented by the direct effect and other unmeasured mechanisms.

Figure 1 summarizes the standardized structural relationships among the principal study variables. ADHD symptoms were strongly associated with executive dysfunction and had additional direct associations with smartphone distraction and academic procrastination. Executive dysfunction was related both to greater smartphone distraction and to greater academic procrastination, while smartphone distraction was associated with greater procrastination. ADHD symptoms, executive dysfunction, smartphone distraction, and academic procrastination were each directly associated with lower academic performance, although academic procrastination had the largest immediate negative association with performance. The figure also illustrates the sequential nature of the proposed model. Specifically, ADHD symptoms contributed to executive-functioning difficulties, which increased vulnerability to smartphone-related attentional interference and academic task delay. Smartphone distraction further intensified procrastination, and procrastination subsequently predicted poorer academic achievement. The persistence of the direct path from ADHD symptoms to academic performance indicated that the effects of ADHD symptoms could not be explained entirely by executive dysfunction, smartphone distraction, and procrastination. Nevertheless, the substantially larger total indirect effect showed that these explanatory mechanisms accounted for most of the relationship between ADHD symptoms and school performance. All displayed structural paths were statistically significant after adjustment for age, gender, grade level, school sector, socioeconomic status, nightly sleep duration, daily smartphone use, previous ADHD diagnosis, city, and the clustering of students within schools.

4. Discussion

The present study examined the relationship between ADHD symptoms and academic performance among Colombian adolescents and tested the roles of executive dysfunction, smartphone distraction, and academic procrastination within an integrated structural model. The findings showed that ADHD symptoms were significantly and negatively associated with academic performance, both directly and indirectly. Adolescents with higher levels of inattention, hyperactivity, and impulsivity tended to obtain lower academic grades, and this association remained significant after demographic characteristics, school-related factors, sleep duration, smartphone-use duration, previous ADHD diagnosis, and city were controlled. The findings further demonstrated that ADHD symptoms strongly predicted executive dysfunction and were also associated with greater smartphone distraction and academic procrastination. Executive dysfunction predicted both smartphone distraction and procrastination, while smartphone distraction further increased procrastination. Among the immediate predictors of academic performance, academic procrastination had the strongest negative effect, followed by executive dysfunction, ADHD symptoms, and smartphone distraction. The total indirect effect of ADHD symptoms on academic performance was substantial, indicating that executive dysfunction, smartphone distraction, and academic procrastination explained most of the association between ADHD symptoms and poorer academic achievement. Nevertheless, the remaining direct effect showed that these variables only partially mediated the relationship.

The negative association between ADHD symptoms and academic performance is consistent with the conceptualization of ADHD as a condition involving persistent difficulties in attention regulation, behavioral inhibition, motivation, and goal-directed behavior. Academic success during adolescence requires sustained concentration, accurate completion of multistep tasks, resistance to distraction, organization of materials, management of deadlines, and persistence despite delayed rewards. These requirements are particularly demanding for adolescents with elevated ADHD symptoms. The present findings are consistent with evidence that ADHD-related impairments can continue beyond childhood and result in accumulated educational difficulties when symptoms are unrecognized or treated late (Chauhan et al., 2025). They also align with research showing that the educational and occupational outcomes of individuals with ADHD are shaped by the severity of attentional and self-regulatory difficulties, as well as by the availability of effective support strategies (Varrasi et al., 2022). The significant direct effect observed in the present study suggests that ADHD symptoms may impair academic functioning through additional mechanisms not fully captured by the three mediators, such as inconsistent motivation, classroom behavioral difficulties, emotional distress, impaired time perception, sleep disturbance, or reduced engagement with instruction.

The strong association between ADHD symptoms and executive dysfunction was one of the most prominent findings. Adolescents with greater ADHD symptom severity reported substantially more difficulty with inhibition, working memory, cognitive flexibility, emotional control, self-monitoring, planning, organization, and task completion. This result is theoretically expected because executive dysfunction is widely regarded as a central feature of ADHD-related impairment. Attention-control deficits can make it difficult for students to select relevant information, maintain concentration, and suppress competing stimuli during learning activities (Luo et al., 2021). Similarly, impairments in hot and cool executive functions can affect both cognitively neutral academic tasks and emotionally or motivationally charged decisions, including whether to begin an assignment or choose an immediately rewarding alternative (Košíková et al., 2024). The magnitude of the association found in this study supports the view that executive difficulties represent more than secondary consequences of poor school performance; rather, they are closely linked to the underlying symptom pattern of ADHD.

Executive dysfunction also had a significant direct negative effect on academic performance. Adolescents with weaker executive functioning tended to obtain lower grades even after ADHD symptoms and other explanatory variables were included in the model. This finding may be explained by the central role of executive processes in nearly every stage of academic work. Working memory is required to retain instructions, integrate new information with prior knowledge, and follow complex problem-solving procedures. Inhibitory control enables students to resist irrelevant thoughts, environmental stimuli, and impulsive responses. Planning and organization support the sequencing of activities, allocation of study time, and completion of assignments. Self-monitoring allows students to detect errors and adjust their behavior, while emotional control helps them tolerate frustration and persist when tasks become difficult. Research on children with listening difficulties has similarly demonstrated that executive-functioning skills are closely related to successful participation in classroom learning and the processing of instructional information (McGrath et al., 2023). The present result is also compatible with evidence that executive functions mediate the effects of ADHD symptoms on other forms of adolescent impairment, including anxiety, suggesting that executive dysfunction acts as a broad mechanism through which ADHD symptoms affect everyday functioning (Haugan et al., 2022).

The indirect pathway from ADHD symptoms through executive dysfunction to academic performance was the largest specific mediation effect. This finding indicates that a considerable portion of the academic disadvantage associated with ADHD symptoms can be understood in terms of impaired self-regulation and cognitive control. The result is consistent with developmental research showing that executive dysfunction, delay aversion, and time-perception deficits predict both ADHD symptoms and early academic performance (Zheng et al., 2022). Adolescents who experience difficulty estimating time, delaying gratification, organizing action, and maintaining goal representations may know what they are expected to do but remain unable to translate intentions into consistent academic behavior. The findings also correspond with systematic reviews identifying executive dysfunction as an important intervention target in ADHD populations (Ramos-Galarza et al., 2024). The development of computerized, artificial-intelligence-supported, and adaptive executive-function programs further reflects the recognized importance of these processes for learning and self-management (Robledo-Castro et al., 2022). Evidence that pharmacological treatment may improve executive functioning and learning-related difficulties similarly supports the practical importance of this pathway (Wilens et al., 2026).

ADHD symptoms were also significantly associated with smartphone distraction. Adolescents with greater symptom severity were more likely to experience attentional interruption from notifications, online vigilance, multitasking, habitual checking, and emotionally motivated smartphone use. This finding can be explained by the reward structure and attentional demands of contemporary digital environments. Smartphones provide rapid, variable, and immediately reinforcing stimulation, whereas academic tasks typically require prolonged effort and offer delayed benefits. Adolescents with ADHD symptoms may therefore

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find smartphone content particularly difficult to resist because impulsivity, reward sensitivity, and difficulty sustaining attention increase the appeal of brief and stimulating digital interactions. Research conducted during the COVID-19 pandemic similarly showed that increased digital media use among children and adolescents with ADHD was associated with meaningful changes in behavioral and emotional functioning (Shuai et al., 2021). Differences in smartphone-related sensory processing between adolescents with ADHD and typically developing peers further suggest that digital devices may interact differently with the attentional systems of adolescents with elevated symptoms (Fabio & Suriano, 2024).

Executive dysfunction significantly predicted smartphone distraction, supporting the proposition that difficulty regulating smartphone use may partly reflect broader deficits in self-control. Adolescents with poor inhibition may respond automatically to alerts or internal urges to check their devices. Those with weak working memory may lose track of the original academic goal after an interruption, while those with emotional-regulation problems may use smartphones to escape boredom, anxiety, or frustration. This interpretation is consistent with evidence that impulsivity, intolerance of uncertainty, and smartphone-management styles are linked to smartphone addiction through warm executive functions (Asheri et al., 2024). The sequential pathway from ADHD symptoms to executive dysfunction, then to smartphone distraction, and finally to academic performance was statistically significant. This pattern suggests that ADHD symptoms may increase digital distraction partly because adolescents lack the executive resources required to control device-related behavior.

Smartphone distraction had a small but significant direct negative effect on academic performance. Although this effect was weaker than the effects of executive dysfunction and academic procrastination, it remained significant after overall smartphone-use duration was controlled. This distinction is important because it suggests that the academic consequences of smartphones depend not only on how long adolescents use them but also on whether their use interrupts learning. A student may spend considerable time on a smartphone for educational purposes without substantial impairment, while another may experience repeated interruptions during a shorter period of use. The finding therefore supports a process-oriented understanding of digital behavior. Reviews have associated problematic internet use with poorer academic outcomes through reduced study time, sleep disruption, impaired self-regulation, and psychological distress (Gül et al., 2022). Excessive smartphone use has likewise been linked to health and psychological difficulties among adolescents and young adults (Wacks & Weinstein, 2021). Broader evidence regarding the negative cognitive effects of digital technology also identifies sustained attention, memory, and cognitive control as potentially vulnerable domains (Žnidarič et al., 2026). However, the relatively modest direct effect found here is compatible with evidence that not every form of digital engagement necessarily produces educational impairment among adolescents with ADHD (Blasco-Fontecilla et al., 2023).

Academic procrastination emerged as the strongest immediate predictor of academic performance. Adolescents who more frequently postponed homework, studying, examination preparation, and other school responsibilities tended to obtain substantially lower grades. This result reflects the direct behavioral consequences of procrastination. Delayed task initiation reduces the time available for careful completion, encourages rushed work, increases the likelihood of missed deadlines, and prevents distributed practice. Procrastination may also increase academic stress, undermine sleep, and lead to repeated experiences of failure that further weaken motivation. The significant association between ADHD symptoms and procrastination suggests that students with elevated symptoms may have particular difficulty converting intentions into timely action. ADHD-related motivational processes may contribute to this pattern because distant academic rewards may be less effective than immediate incentives in directing behavior (Morsink et al., 2021). Furthermore, the overlap between procrastination and executive dysfunction indicates that delayed task initiation may reflect failures in planning, inhibition, working memory, and emotional regulation rather than simple unwillingness to study.

Executive dysfunction and smartphone distraction both significantly predicted academic procrastination. These findings suggest that procrastination operates as a final common behavioral pathway through which cognitive and digital-regulation difficulties influence performance. Students with executive dysfunction may fail to break large tasks into manageable steps, underestimate the time required, forget deadlines, or avoid tasks associated with frustration. Smartphone distraction can intensify this process by providing an immediate and easily accessible alternative to academic activity. Repeated checking interrupts task initiation and continuity, making academic work feel more effortful and increasing the likelihood of further postponement. The significant sequential mediation from ADHD symptoms through smartphone distraction and procrastination to academic performance supports this interpretation. Sleep may also reinforce the cycle because smartphone use, ADHD-related dysregulation, and homework problems can interact with inadequate sleep, reducing next-day attention and persistence (Smets et al., 2025).

The longest sequential pathway—from ADHD symptoms to executive dysfunction, from executive dysfunction to smartphone distraction, from smartphone distraction to academic procrastination, and from procrastination to poorer performance—was also significant. Although smaller than the simpler indirect effects, this pathway provides an integrated account of how neurodevelopmental symptoms may be translated into everyday academic underachievement. Adolescents with ADHD symptoms may first experience difficulty controlling attention and behavior. These deficits may reduce their capacity to manage smartphone cues and immediate digital rewards. Repeated distraction may then interfere with task initiation and promote procrastination, ultimately reducing academic performance. This sequence is consistent with the idea that ADHD-related educational impairment develops through interacting cognitive, motivational, technological, and behavioral processes rather than through a single isolated deficit.

The model explained a substantial proportion of the variance in academic procrastination and academic performance. Nevertheless, the persistence of a direct relationship between ADHD symptoms and performance indicates that additional mechanisms remain relevant. Emotion-regulation difficulties may interfere with academic functioning by increasing frustration, avoidance, and sensitivity to failure (Malik & Namgyal, 2024). Depressive and other cognitive vulnerabilities associated with ADHD may also reduce concentration, confidence, and persistence (Mayer et al., 2021). Variations in decision-making and immediate reward preference may further shape academic choices (Chachar & Shaikh, 2024). Moreover, biological, developmental, family, and educational factors may influence both ADHD symptoms and learning outcomes (Gkintoni et al., 2025). The findings should therefore be interpreted as evidence for an important set of pathways rather than a complete explanation of academic performance.

5. Conclusion

The results also have implications for intervention. The strong role of executive dysfunction suggests that interventions targeting planning, working memory, inhibition, organization, and self-monitoring may improve academic functioning. Systematic reviews support the use of cognitive training, behavioral programs, neurofeedback, physical activity, and combined executive-function interventions in ADHD populations (Ramos-Galarza et al., 2024). Physical activity has shown beneficial effects on executive functions in children and adolescents with ADHD (Song et al., 2023), while mobile and gamified applications may provide engaging forms of early intervention when they are deliberately structured to support rather than distract students (Kakoura et al., 2024). Artificial intelligence and virtual reality may also contribute to individualized cognitive assessment and intervention planning (Yılmaz et al., 2025). However, digital interventions should be implemented carefully because the same devices used therapeutically can also become sources of distraction.

6. Limitations & Suggestions

Several limitations should be considered when interpreting the findings. First, the cross-sectional design prevents firm conclusions regarding temporal or causal direction. Although the proposed ordering of ADHD symptoms, executive dysfunction, smartphone distraction, procrastination, and academic performance was theoretically grounded, reciprocal relationships are possible. For example, repeated academic failure may intensify avoidance, emotional distress, and smartphone use. Second, executive dysfunction, smartphone distraction, and academic procrastination were primarily assessed through adolescent self-report, which may be influenced by recall errors, social desirability, and shared-method variance. Third, although ADHD symptoms were rated by teachers, the measure was not intended to establish a clinical diagnosis, and symptoms occurring outside the school setting were not independently assessed. Fourth, the sample was drawn from urban schools in Bogotá, Medellín, and Cali, which may limit generalizability to rural adolescents, students who are not enrolled in school, and populations from other Latin American countries. Fifth, academic performance was based on school grades, which are ecologically meaningful but may reflect differences in teacher judgment, curriculum, grading standards, and classroom participation. Finally, potentially relevant variables such as intelligence, learning disorders, parenting practices, teacher support, medication adherence, family conflict, and specific patterns of social media use were not included in the final model.

Future studies should employ longitudinal designs to determine whether ADHD symptoms prospectively predict changes in executive functioning, smartphone distraction, procrastination, and academic performance across adolescence. Cross-lagged and intensive longitudinal methods could clarify reciprocal relationships and identify whether digital distraction precedes procrastination or whether students use smartphones more frequently after delaying difficult tasks. Future research should combine self-report measures with parent and teacher ratings, passive smartphone-use data, behavioral executive-function tasks, sleep monitoring, and objective records of homework completion. Studies should also examine whether the proposed pathways differ according to sex, age, ADHD presentation, learning-disability status, socioeconomic background, school type, treatment status, and urban or rural context. Experimental and intervention research is needed to determine whether improvements in executive functioning, smartphone management, or procrastination produce measurable gains in academic achievement. Finally, culturally responsive studies in different regions of Colombia and other Latin American countries would help establish the generalizability of the model.

Schools should screen for attentional and executive-functioning difficulties when adolescents display persistent underachievement, missed deadlines, disorganization, or inconsistent performance rather than attributing these behaviors solely to low effort. Support plans should combine structured academic routines, explicit instruction in planning and task breakdown, short-term deadlines, visual schedules, reminders, and regular progress monitoring. Students should be taught practical smartphone-management strategies, including disabling nonessential notifications, placing devices outside the immediate study area, using scheduled checking periods, and separating educational applications from entertainment content. Procrastination interventions should emphasize immediate task initiation, manageable work intervals, implementation intentions, realistic time estimation, and reinforcement of incremental progress. Collaboration among students, families, teachers, school psychologists, and healthcare professionals is essential to ensure that academic expectations, behavioral supports, and treatment plans are coordinated and adapted to each adolescent's needs.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contributed to this article.

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