Article

Is Screen Time Throughout Adolescence Related to ADHD? Findings from 1993 Pelotas (Brazil) Birth Cohort Study

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Abstract

Objective: This study investigated the association between screen time in adolescence and Attention Deficit Disorder (ADHD) at 22 years old. **Method:** A sample of 2333 participants aged 11 years old without ADHD from the 1993 Pelotas Birth Cohort Study (Brazil) was followed up until the age of 22. Screen time variables included time spent in television, video game and computer at 11, 15, and 18 years old. ADHD was assessed at 22 years. **Results:** ADHD symptoms at 22 years was positively associated with television time at 11 years, computer time at 18 years and total screen time at ages 11, 15, and 18 years. Television time at 11 years and total screen time at 18 years were associated with diagnosis of ADHD at 22 years of age. **Conclusions:** Our findings may contribute to future investigations of possible explanatory avenues for these associations.

Keywords

screen time, attention deficit disorder, cognition, longitudinal, adolescents

Introduction

Attention deficit hyperactivity disorder (ADHD) is a disorder that includes behavioral and cognitive features such as inattention and impulsivity/hyperactivity (American Psychiatric Association, 2014). Given the potential impact on school performance in children and adolescents, ADHD is an issue of concern to medical professionals, psychologists, and families (Rohde et al., 2006).

Although the evidence suggests that clinically significant attention problems have a strong biological and genetic basis (Barkley, 2002), many researchers have sought to find environmental risk factors for these problems.

Among the environmental factors is the time spent on screen activities, such as watching television, playing video games, and using the computer, called screen time (Owen et al., 2010). The recommendations suggest limit screen time for children and adolescents a maximum of just 2 hours per day (Strasburger et al., 2013). In several countries, there is an increase in the prevalence of excessive screen time (≥2 hours/day) among children and adolescents, probably due to the drastic changes in the use of media and the fast pace of the introduction of new technologies in the last decade (Bucksch et al., 2016; Rideout, 2015; Schaan et al., 2018).

The first studies on the effects of screen time on attention problems reported a positive correlation between the amount of television viewed by children younger than 3 years and symptoms related to ADHD, such as attention problems and hyperactivity (Christakis et al., 2004; Zimmerman & Christakis, 2007). These findings stirred up worldwide debate on the effects of screen time on attention problems, which generated an increase in production of literature on the topic (Valkenburg & Piotrowski, 2017).

A meta-analysis of 45 empirical studies that investigated the relationship between media use and ADHD-related behaviors in children and adolescents showed inconsistent findings, and that studies with adolescents are still scarce (Nikkelen et al., 2014).

The effects of screen time on adolescence are currently unclear. However, adolescence is a sensitive period for the modification and adaptation of cognitive processes, including attention (Christakis et al., 2018). In addition, it is necessary to

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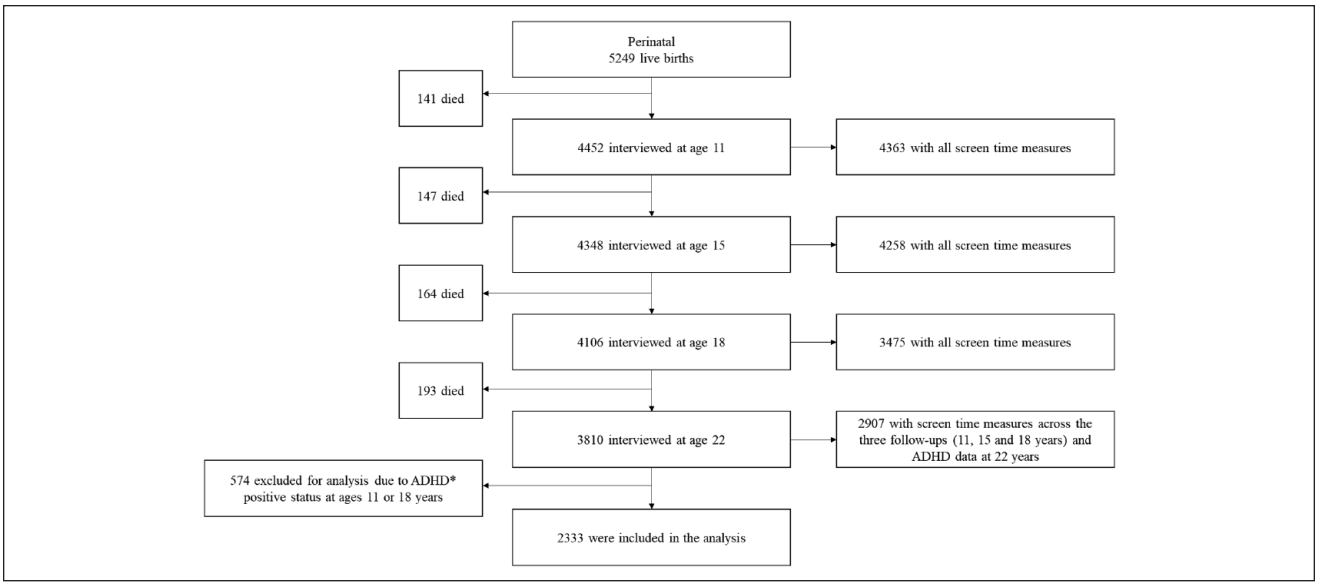

Figure 1. Flow chart of data collected on screen time and attention deficit hyperactivity disorder (ADHD) in the 1993 Pelotas Birth Cohort Study.
*ADHD at 11 years: scores on the SDQ hyperactivity scale (parent report) equal or higher to 8 points and associated with impairment, defined by at least 1 point in the impact supplement. ADHD at 18 years: DSM-5 criteria.

understand the effects of separate television, videogame, and computer time. These three media activities may serve quite different purposes, which can lead to different effects on ADHD. Unlike television, devices such as video games and computers allow for interactivity (Vorderer, 2000). Also, whereas playing video games and using the computer is typically a primary activity, television viewing is often used as a secondary activity (Carnagey & Anderson, 2004).

The scarcity of longitudinal studies available on the association between screen time and ADHD in adolescents as well as the need for studies that control for potentially confounding factors, justify further investigations on this relationship. The aim of this study was to investigate the association between screen time in adolescence and ADHD at 22 years old.

Methods

Participants

Information was collected from participants enrolled in the 1993 Pelotas (Brazil) Birth Cohort Study. The original cohort included 5,249 of the 5,265 children born in 1993 in Pelotas, a medium-sized city in the state of Rio Grande do Sul, Brazil. All participants from the original cohort were invited to follow-ups in 2004, 2008, 2011, and 2015, when they were aged 11, 15, 18, and 22 years. Of the 5,249 participants included in the perinatal follow-up (baseline), 3,810 attended the 11, 15, 18, and 22-year follow-ups (retention rate of 76.3%; Figure 1).

Before participating in the study, written parental consents were obtained. The study protocols were approved by the Ethics Committee of the Medical School from the Federal University of Pelotas. More details of the methods have been reported previously (Gonçalves et al., 2018).

Screen Time

Information about screen time was collected when adolescents were 11, 15, and 18 years. Screen time was self-reported through face-to-face interviews using a standardized questionnaire, including questions about time spent watching television, playing video games, and using a computer, excluding weekend. Total screen time was calculated as the sum of time spent in these three domains.

Attention Deficit Disorder (ADHD)

The assessment at 11 years of age included data on ADHD symptoms using the Brazilian Portuguese Version of the Strengths and Difficulties Questionnaire (SDQ, parent-reported version). The cutoff point of 8 or more points on the SDQ hyperactivity scale was adopted (85.7% sensitivity and 67.4% specificity for the ADHD diagnosis) (Anselmi et al., 2010).

At the 18- and 22-year follow-ups, ADHD was assessed by trained psychologists using specific module for Attention deficit hyperactivity disorder modified from the Mini-International Neuropsychiatric Interview (Amorim, 2000). The ADHD assessment was performed with a structured

interview according to DSM-5 criteria (Supplemental Table 1) (Matte et al., 2015).

Based on DSM-5 criteria, adolescents who reported experiencing six more symptoms in either inattention or hyperactivity-impulsivity categories were classified as positive for ADHD. For the present study, we did not require DSM-5 criterion B (age at onset).

Confounding Variables

The confounding variables included were defined *a* priori based on the literature on the use of electronic devices and ADHD (Beyens et al., 2018). From the perinatal period, the following variables were included: sex (female and male), skin color (white, black, brown, and others), household income (in minimum wage), and maternal information—maternal education (years), alcohol consumption (no/yes) and smoking during pregnancy (no/yes). From the 11-year follow-up, the following confounding variables were included: reading habit and maternal common mental disorder.

We defined reading habit as the number of days per week that the adolescents read newspapers, magazines, or books (Never, 1–4 and ≥5). Maternal common mental disorder was assessed using the Brazilian version of the Self-Reporting Questionnaire (SRQ-20) (Mari and Williams, 1986; Gonçalves et al., 2008). The cutoff point of 8 or more points was adopted (Gonçalves et al., 2008).

Statistical Analysis

Descriptive statistics were used to summarize the sample characteristics (absolute and relative frequency). We used the chi-square test of heterogeneity to compare the proportion of ADHD diagnosis at 22 years old, according to the confounding variables.

To elucidate the associations between screen time measures across the three follow-ups (11, 15, and 18 years) and ADHD at 22 years, the analyses were performed in four steps. First, we excluded from the sample those adolescents with attention difficulties and hyperactivity at 11 years old according to the SDQ and those positive for ADHD at 18 years old ($n = 574$; Figure 1). The interactions of screen time measures (hours/day) with sex regarding the ADHD at 22 years old were tested; however, there was no statistical significance.

Second, unadjusted and adjusted analyses of the association between screen time measures at each age (11, 15, and 18 years) and ADHD symptoms at 22 years, were performed. Symptom counts were modeled using a Poisson distribution. Incident rate ratio (IRR) effect sizes were calculated by exponentiating Poisson regression coefficients and display the proportional change in symptom counts with each unit increase in screen time measures (hour/day). Third, crude and adjusted logistic regressions were used to examine the relationship between the diagnosis of ADHD at 22 years and screen time measures at 11, 15, and 18.

The adjusted Poisson and logistic regressions model incorporated the following confounding variables: sex, skin color, household income, reading habit, and maternal information—maternal education, alcohol consumption, smoking during pregnancy, and maternal common mental disorder.

Additional analysis was performed with the cumulative screen time measures during adolescence. To evaluate the association of cumulative screen time measures with symptoms and diagnosis of ADHD at age 22, four continuous variables were created through the sum of hours spent on each screen time measures at 11, 15, and 18 years of age, and then these values were divided by three. The results of this analysis are presented in the Supplemental Table 3. Additional sensitivity analyses are summarized below and detailed in supplementary material.

All analyses were conducted using STATA 14.0 (Stata Corp., College Station, USA) and statistical significance was set at 5% (in interaction analyses 10%).

Results

Of the 3810 participants in the original cohort, 3057 adolescents (80.2%) had screen time data at all follow ups and ADHD measure at age 22 (Figure 1). The analytical sample corresponded to 38.7% of original cohort, with the baseline characteristics of this sample are compared with those of the original cohort (perinatal follow-up) in Supplemental Table 1. There was no difference in sociodemographic characteristics between the perinatal follow-up and participants who were included. Adolescents positive for ADHD at 22 years of age were less likely to be included in the analysis, compared to those positive for ADHD at 11 or 18 years of age excluded (Supplemental Table 2).

The characteristics of the studied sample are described in Table 1. Most adolescents were female (52.8%), white (64.9%), and with an income of up to three minimum wages (41.0%). At 11 years old, 23.3% used to read 5 or more days a week. Regarding the characteristics of the mothers, almost half had 5 to 8 years of schooling and 45.3% had common mental disorder. During pregnancy, a third of the mothers reported having smoked and 5.4% having consumed alcohol. The distribution of screen time measures in the three follow-ups are shown in Figure 2. At 22 years, the distribution of ADHD symptoms had a mean (SD) of 5.07 (3.78). The prevalence of ADHD diagnosis at 22 years was 14.6% (95% CI = 13.2%—16.1%).

The crude and adjusted analyses of the associations between continuous screen time measures (hour/day) and ADHD symptoms at 22 years are shown in Table 2. After the adjustment, the amount of time that adolescents reported spending watching television at ages 11 and 18 years was

Table 1. Descriptive Characteristics of The Sample. 1993 Pelotas Birth Cohort (*N* = 2,637).

		ADHD at 22	
	N (%)	*N* (%)	*p*-Value*
Adolescent data			
Sex			.001
Male	1,101 (47.2)	132 (12.0)	
Female	1,232 (52.8)	208 (16.9)	
Skin color			.006
White	1,474 (64.9)	189 (12.8)	
Black	324 (14.3)	53 (16.4)	
Brown	382 (16.8)	68 (17.8)	
Others	92 (4.0)	14 (15.2)	
Household income (in minimum wage; *N* = 3,007)			.286
≤1	415 (18.1)	67 (16.1)	
1.1–3	940 (41.0)	142 (15.1)	
3.1–6	587 (25.6)	73 (12.4)	
6.1–10	181 (7.9)	20 (11.0)	
>10	170 (7.4)	26 (15.3)	
Reading habit at 11 years (days/week)			.650
Never	620 (26.6)	97 (15.6)	
1–4	1,169 (50.1)	168 (14.4)	
≥5	543 (23.3)	75 (13.8)	
Maternal data			
Maternal education (years)			.728
0–4	613 (26.3)	87 (14.2)	
5–8	1086 (46.6)	164 (15.1)	
9–11	440 (18.9)	66 (15.0)	
≥12	190 (8.2)	23 (12.1)	
Maternal common mental disorder** (*N* = 3040)			.216
No	1,271 (54.7)	175 (13.8)	
Yes	1,052 (45.3)	164 (15.6)	
Smoking during pregnancy			.125
No	1613 (69.1)	223 (13.8)	
Yes	720 (30.9)	117 (16.3)	
Alcohol consumption during pregnancy			.895
No	2,206 (94.6)	322 (14.6)	
Yes	127 (5.4)	18 (14.2)	

*Chi-square test.
**≥7 Points in the Self-Reporting Questionnaire (SRQ-20).

positively associated with symptoms of ADHD (IRR = 1.02; 95% CI: 1.01–1.03 and IRR = 1.02; 95% CI: 1.01–1.03, respectively). The video game time at 15 years was positively associated with ADHD symptoms at 22 years. However, at 18 years, video game time showed an association in the opposite direction (IRR = 0.98; 95% CI: 0.96–1.00). Adolescents who spent more time using computer at age 18 reported more ADHD symptoms at 22 years (IRR = 1.01; 95% CI: 1.01–1.02). The total screen time at ages 11, 15, and 18 years were positively associated with ADHD symptoms at 22 years.

Table 3 shows the results of the associations between screen time measures across the three follow-ups and ADHD diagnosis at 22 years old. After the adjustment, the television time (hours/day) at 11 years remained associated with the ADHD diagnosis at 22 years of age. For every one-unit increase in television time (hour/day) at 11 years, the estimated odds of ADHD at 22 increases by 7%. Also, the total screen time at 18 years was positively associated with ADHD at 22 years in adjusted analysis (OR = 1.05; 95% CI: 1.01–1.09).

Sensitivity analyses found no significant bidirectional associations in screen time measures associated with ADHD symptoms at age 22 (Supplemental Figure 2).

Discussion

Most previously reported relations of screen time measures with ADHD were cross-sectional (Nikkelen et al., 2014).

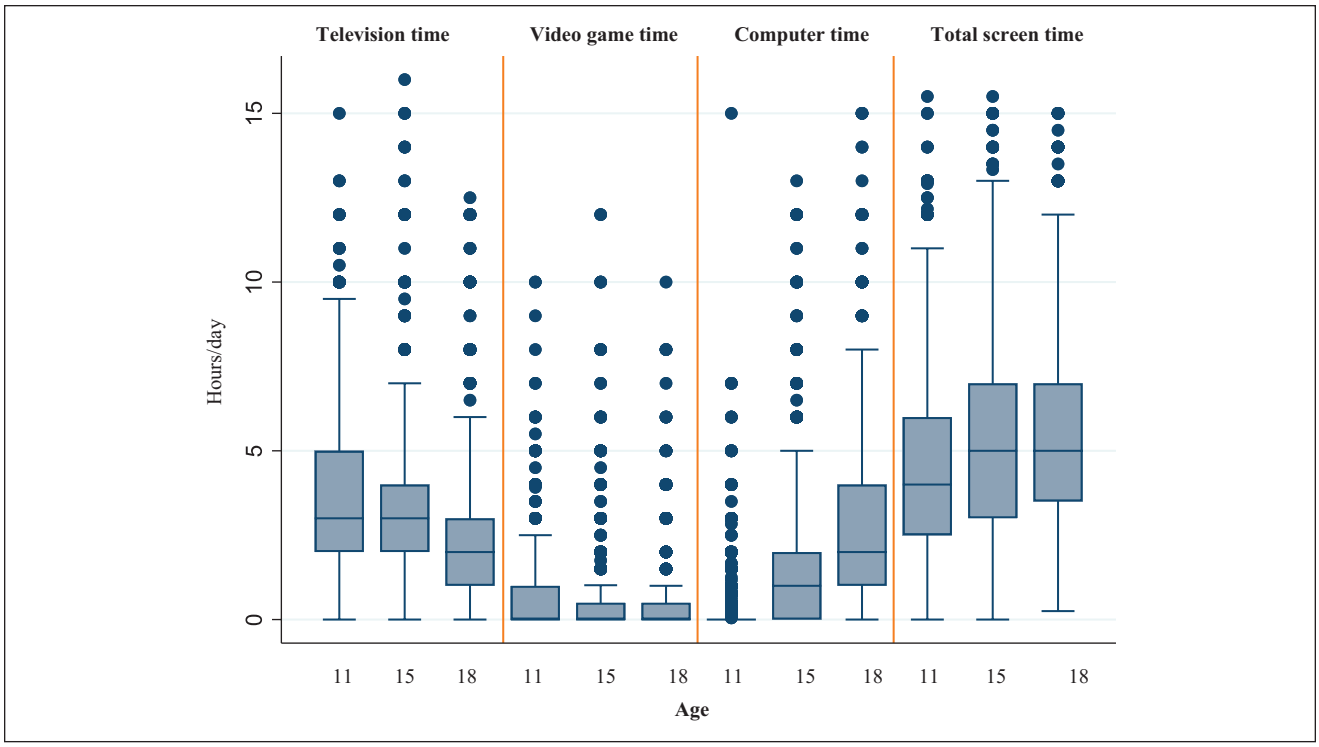

Figure 2. Distribution of screen time measures at ages 11, 15, and 18 years. One thousand nine hundred ninety-three Birth cohort in Pelotas.

Table 2. Associations of Screen Time Measures (Hours/Day) with ADHD Symptoms at 22 ($N = 2,294$).

	Unadjusted analysis		Adjusted analysis[a]	
	IRR (95% CI)	*p*-Value	IRR (95% CI)	*p*-Value
At 11				
Television	1.01 (1.01–1.02)	.002	1.02 (1.01–1.03)	<.001
Videogame	1.00 (0.98–1.02)	.868	1.00 (0.98–1.02)	.687
Computador	1.00 (0.98–1.02)	.977	1.02 (0.99–1.04)	.204
Total screen time	1.01 (1.01–1.02)	<.001	1.01 (1.01–1.02)	<.001
At 15				
Television	1.00 (1.00–1.01)	.022	1.00 (1.00–1.01)	.087
Videogame	1.01 (1.00–1.03)	.014	1.02 (1.00–1.05)	.045
Computador	1.00 (0.99–1.01)	.519	1.01 (0.99–1.02)	.155
Total screen time	1.00 (1.00–1.00)	.277	1.01 (1.00–1.02)	<.001
At 18				
Television	1.03 (1.02–1.04)	<.001	1.02 (1.01–1.03)	<.001
Videogame	0.98 (0.96–0.99)	.009	0.98 (0.96–1.00)	.022
Computador	1.01 (1.00–1.02)	.004	1.01 (1.01–1.02)	.001
Total screen time	1.01 (1.01–1.02)	<.001	1.01 (1.01–1.02)	<.001

[a]Adjustment for confounding variables: sex, skin color, household income, maternal education, alcohol consumption during pregnancy, smoking during pregnancy, maternal common mental disorder, and reading habit at 11 years.

The association of screen time and ADHD remains unclear in the previous literature due to limitations in assessing exposure and applying designs that are unable to withstand temporal or causal inferences. The current study found longitudinal evidence on this topic in 11-year-old adolescents without ADHD followed up to 22 years of age.

In this general population longitudinal study, the television time at age 11 and 18 years was positively associated

Table 3. Associations of Screen Time Measures (Hours/Day) with ADHD at 22 ($N = 2,186$).

	Unadjusted analysis		Adjusted analysis[a]	
	OR (95% CI)	*p*-Value	OR (95% CI)	*p*-Value
At 11				
Television	1.07 (1.02–1.12)	0.010	1.07 (1.02–1.12)	0.008
Videogame	0.89 (0.79–1.00)	0.056	0.94 (0.83–1.07)	0.353
Computador	0.95 (0.81–1.11)	0.493	0.99 (0.84–1.17)	0.912
Total screen time	1.02 (0.98–1.07)	0.255	1.04 (0.99–1.08)	0.192
At 15				
Television	0.99 (0.98–1.01)	0.425	0.99 (0.98–1.01)	0.933
Videogame	1.00 (1–1.01)	0.028	1.00 (0.99–1.01)	0.172
Computador	1.00 (0.99–1.01)	0.056	0.99 (0.99–1.00)	0.069
Total screen time	1.00 (1.00–1.00)	0.856	0.99 (0.99–1.01)	0.783
At 18				
Television	1.07 (1.01–1.14)	0.021	1.06 (0.99–1.13)	0.057
Videogame	0.91 (0.79–1.04)	0.178	0.97 (0.84–1.12)	0.635
Computador	1.04 (0.98–1.09)	0.206	1.05 (0.99–1.10)	0.120
Total screen time	1.05 (1.01–1.09)	0.012	1.05 (1.01–1.09)	0.007

[a]Adjustment for confounding variables: sex, skin color, household income, maternal education, alcohol consumption during pregnancy, smoking during pregnancy, maternal common mental disorder, and reading habit at 11 years.

with ADHD symptoms at 22 years in adjusted analysis. Other longitudinal studies corroborate our findings (Johnson et al., 2007; Landhuis et al., 2007). Landhuis et al. (2007) using data from the offspring of participants in the 1972 Birth Cohort from Dunedin, New Zealand, found those who watched 2 hours, and particularly those who watched 3 hours, of television per day between the ages of 5 to 11 years had above-average symptoms of attention problems at 15, adjusting for gender, early attention problems, early cognitive ability, and childhood socioeconomic status.

A study conducted in the United States, which investigated the association between watching television and educational and intellectual outcomes during adolescence found that adolescents who watched three or more hours/day of television at age 14 were more chance to have one or more symptoms of attention-deficit/hyperactivity at age 16, compared to those who watched less than 3 hours/day (OR = 1.44; 95% CI = 2.26–5.93) (Johnson et al., 2007).

It is plausible to think that negative effects of the use of television on the attentional capacities are related to the fast changes of scene and the high levels of sensorial stimulus of the watched content (Lillard et al., 2015). For example, one experimental study with university students (± 22 years old) showed that after 30 min viewing a highly exciting action clip, viewers performed worse on a concentration test when compared to those exposed to 30 minutes of a banal tennis match (Maass et al., 2011).

In addition, the limited capacity model of television viewing suggests that the processing of television content depletes the cognitive resources needed for tasks that require attentional capacity (Lang, 2000). Watching television entails attending to and encoding messages in auditory and visual streams, processing those messages and storing and retrieving them dynamically in order to continuously interpret newly arriving messages (Lillard et al., 2015). Although the precise duration of such overload effects on subsequent information processing is unknown, immediate short-term deficiencies have been documented (Lang et al., 2013; Lillard et al., 2015).

Some authors suggest that time spent on watching television is time away from other activities, such as reading, that train attention (Lillard et al., 2015). To discard this hypothesis, we adjusted the analysis for reading habits at age 11.

The direction and magnitude of the associations between video game time variables and ADHD symptoms at 22 changed across the adolescent period in this cohort. Given that no significant association was found between cumulative video game time during adolescence and ADHD symptoms (Supplemental Table 3), this finding may reflect the lack of effect of video game time on ADHD. Previous studies suggest that video game influences on increased and attention deficit symptoms are inconsistent (Beyens et al., 2018).

As a result of the constantly changing environment of the media use, the present study did not contemplate the effects of increasing access to mobile devices and social networks because, at the time of data collection, these devices were not yet popular in Brazil. Our results showed a positively association of computer time at 18 years and total screen time across the three follow-ups (11, 15, and 18 years) with ADHD symptoms at 22 years. Although modern and traditional forms of digital media (e.g.,

videogame console playing and computer using) are not comparable, these findings are similar to those by Ra et al. (2018) who found a positively association between higher frequency of modern digital media use at baseline (ages 15 and 16 years) and subsequent symptoms of ADHD over a 24-month follow-up.

A possible explanation is related to the purpose of the use of media by adolescents. For example, in the study by Ra et al., playing games by yourself and video chatting had the highest odds ratio for ADHD symptoms (OR = 1.97; 95% CI: 1.40–2.78 and OR = 2.11; 95% CI: 1.39–3.22, respectively). These activities are also carried out by using video game console and computer. In addition, it can be assumed that several screen activities require efforts of attention and frequent use could lead to difficulties in filtering out irrelevant information. If adolescents get used to allocating their attention to several media concurrently, they may have difficulty focusing their attention in situations that require longer periods of attention (e.g., doing homework)(Junco & Cotten, 2011; Rosen et al., 2013). Studies show that human information processing is a limited capacity resource and that when multitasking depletes the resource there is a response cost (e.g., accuracy, completion time) to productivity (Dye et al., 2009; Lui & Wong, 2012; Sparrow et al., 2011).

The Nikkelen et al. (2014) meta-analysis provided mixed evidence for bidirectional relationships between media use and ADHD-related behaviors. Only a study by Gentile et al. (2012), found evidence for a bidirectional relationship between video game playing (both overall and violent) and attention problems and impulsivity. To discard this hypothesis, we assessed the association between ADHD symptoms at ages 11 and 18 years old and screen time measures (Supplemental Figure 2). Besides, we excluded ADHD-positive participants at age 11 and 18 years from the sample.

Our study has several strengths. It was carried out in a large population-based sample with high rates of retention and follow-up, minimizing the likelihood of selection bias. The longitudinal design allows the assessment of temporality between screen time measures and later adolescent ADHD. In addition, analyzes using continuous symptom measurements of ADHD were performed to reduce the problem of overestimating or underestimating ADHD diagnosis due to misclassifying individuals with symptom levels close to diagnostic cut points. Regarding the complexity of the phenomenon studied, in our analyses, we control for variables that can influence the amount of screen time and the development of attention skills, such as a wide variety of sociodemographic variables and psychosocial factors, such as maternal education and family income (Filippetti, 2011; Sarsour *et al*., 2011).

It is also important to note that the data collected impose limitations on the analyzes. First, a main limitation is that the content of the television, video game, and computer was not available. Second, the recall bias related to self-reported screen time might be a limitation of this study. Third, there is no data on screen time before age 11, which makes it impossible to assess the effects of television, video game, and computer time in preschool, for example, on the ADHD.

In conclusion, the results showed a statistically significant but modest association between screen time measures and subsequent symptoms and diagnosis of ADHD in adolescents. Additional research is needed to determine whether this association is causal, including information about the content watched on each device and the time dedicated to each one.

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Supplemental Material

Supplemental material for this article is available online.

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