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ORIGINAL RESEARCH

Physical Activity, Screen Time, and Sleep in Children With ADHD

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Background: Children with attention deficit hyperactivity disorder (ADHD) are at increased risk for poor health and obesity. The authors describe obesity-related movement behaviors in children with ADHD, determine higher risk groups, and compare with children with other disorders. **Methods**: Physical activity (PA), sleep, and screen time of children with ADHD (aged 6–18 y) were compared with recommendations and with behaviors of children with autism, asthma, and a normative group using 2011 National Survey of Child Health data. **Results**: Approximately one-third of children with ADHD participated in daily PA and half in sports in the past year. Older children with ADHD were less likely to get daily PA, get enough sleep, and limit screen time to <2 hours per day. Obese children had lower odds of daily PA. Children who had lower socioeconomic status, or severe ADHD, had lower odds of sports participation. Children with ADHD had 50% lower odds of sports participation than children with asthma. **Conclusions**: Children with ADHD did not engage in recommended amounts of PA, sleep, and screen time. Children with ADHD who are older, poor, obese, and/or with more severe symptoms are at higher risk for suboptimal movement behaviors. These domains represent novel treatment targets in ADHD youth.

Keywords: movement behaviors, obesity, sports, pediatrics, public health

Attention deficit hyperactivity disorder (ADHD) is the most prevalent neurodevelopment disorder in childhood affecting 11% of school-aged children[1] and associated with wide-ranging impairments,[2] including academic underachievement, social problems, substance abuse, and negative health outcomes including lower life expectancy.[3,4] Childhood ADHD has been associated with pediatric obesity and may be a risk factor for adult obesity.[5–7] Although it is often assumed that children with ADHD are sufficiently or even highly (hyper) active, youth with ADHD may not be engaging in optimal movement behaviors for health.[8] Thus, there is accumulating support for the importance of all components of the movement continuum (sleep, sedentary time, and physical activity [PA]) for obesity, general health, and neurocognitive development.[9–11]

Physical activity is a modifiable health behavior and associated with sports participation in children.[12] However, children with ADHD may encounter unique challenges to participating in PA and sports, including increased rates of noncompliant and disruptive behaviors.[13] This is concerning because engaging in PA (through sports or otherwise) is associated with numerous physical and mental health benefits[14] and has been found to enhance brain development and cognition.[15–17] Indeed, several studies have documented the benefits of PA for children with ADHD, including reductions in ADHD symptoms, improved social-emotional functioning, and academic achievement.[18–20] PA also has been found to improve executive functions (EF), which are defined as cognitive processes that govern self-regulation, problem solving, and inhibition of impulses.[21] EF are found to be impaired in children with ADHD, and EF deficits underlie behavioral symptoms of ADHD such as impulsivity and distractibility[22,23] as well as numerous health-risk behaviors.[24] PA is found to improve EF including sustained attention and response inhibition in children with ADHD, which may benefit overall functioning and healthy behaviors.[25]

Sedentary activities, such as screen time and sleep, are also associated with obesity.[26] Moreover, excessive screen time is associated with negative cognitive and mental health outcomes, including inattention, internalizing problems, and low self-esteem.[27,28] In addition, approximately 70% of youth with ADHD have bedtime resistance and sleep-onset difficulties.[29] The regulation of arousal and sleep also plays a restorative role in brain functioning[11] and is linked to poor executive functioning. Parents of children with ADHD may have difficulty in fostering healthy sleep habits and limiting sedentary behaviors such as screen time, for various reasons including the fact that they may have ADHD themselves.[30]

Previous studies using nationally representative samples from 2003 to 2007 have documented poor obesity–related health behaviors in children with ADHD.[5,8] We sought to describe obesity-related movement behaviors in a more recently obtained nationally representative sample of children with ADHD, to determine risk factors for suboptimal health behaviors, and to compare outcomes to those of children with other neurodevelopmental or medical conditions. We hypothesized that children with ADHD, on average, would attain less PA and sleep and more screen time than is recommended. We also wanted to explore how the health behaviors of children with ADHD compare with those of children with other chronic health conditions to examine whether ADHD is specifically associated with differences in movement behaviors. Thus, we compare health behaviors in a sample with ADHD to those of children with autism spectrum disorder (ASD, another neurodevelopmental diagnosis) and asthma (a common and chronic physical health diagnosis) as well as a normative sample with none of these diagnoses.

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Methods

National Survey of Child Health Data

The National Survey of Child Health is a population-based, nationally representative sample of US children.[31] Interviews were conducted by telephone (including cell phones) with a parent or guardian of the sampled child in the household. This study was deemed exempt by the Seattle Children's Hospital Institutional Review Board.

Study Sample

We conducted analyses of the 2011 cohort, which is the most recent time period for which data are available. This study focused on school-age children aged 6–18 years with a parent-reported diagnosis of 1 of 3 target conditions (ADHD, ASD, and asthma) or none of the target conditions (normative control).

Diagnosis

Attention deficit hyperactivity disorder, ASD, and asthma diagnoses were determined based on parent report that a health care provider had told them that their child had the condition *and* that their child had the condition at the time of the survey. Parents categorized the condition as mild, moderate, or severe, and for children with ADHD, current use of medications was ascertained.

Movement Behaviors

Parents were asked to report on participation in organized sports, PA, sleep, and media use (average weekday use of television, computers, other media use, not for schoolwork). Responses were dichotomized to align them with American Academy of Pediatrics recommendations regarding engaging in these health behaviors.[32] Measures of PA and sleep sufficiency were dichotomized (every day vs less often). Total media use, in hours, was calculated as the sum of individual questions and dichotomized (<2 h/d vs ≥2 h/d, per the recommendation for this age). Additional questions related to media use included family rules and limits and presence of television in the bedroom. See Table 1 for additional details on the measures.

Sociodemograhpics

Parents reported demographic factors including the child's age, sex, race/ethnicity, primary household language, maternal education, and eligibility for free/reduced lunch. Parents reported the child's height and weight that were used to determine a body mass index.

Statistical Analysis

Analyses were adjusted for survey design factors including cluster sampling (PID), stratification (STATE, SAMPLE), and unequal probability weighting (NSCHWT). Categorical and ordinal responses were summarized by weighted percentages, and continuous measures were summarized by weighted means and SEs.

Diagnosis was entered into a series of multivariable logistic regression models predicting each health behavior among children with ADHD compared with children with ASD, asthma, or none of these conditions. Based on a priori hypotheses, models were adjusted for age (continuous), sex, race, ethnicity, socioeconomic status (free/reduced lunch eligibility), condition severity, overweight (≥85th–94th percentile)/obese (≥95th percentile) status, and ADHD medication use. Odds ratios and associated 95% confidence intervals are reported. Analyses were adjusted for multiple comparisons using the false discovery rate method. Analyses were conducted in SAS 9.4 (SAS Institute, Cary, NC) with significance level $\alpha = .05$.

Results

Demographic and descriptive characteristics by condition are presented in Table 2. The average age of children in all 4 groups was between 11 and 12 years old. Two-thirds of children with ADHD reported being eligible for free/reduced lunch. Thirty-two percent of children with ADHD were reported to be overweight or obese, and 70% of children were reported to currently be using medication for ADHD.

Descriptive data for movement behaviors by condition are presented in Table 3. Across all conditions, less than one-third of children were reported to get at least 20 minutes of PA daily. Across all conditions, children exceeded the recommended 2 hours of screen time per day when television and computer/other device were combined and about half had televisions in their bedroom. The large majority of parents across the groups reported having limits on screen time and monitoring screen content.

In Table 4, for children with ADHD, we summarize the odds ratios for factors associated with meeting recommendations for the various movement behaviors. Children who were older had lower odds of participating in daily PA, getting enough sleep, and limiting screen time to less than 2 hours per day. In unadjusted analyses, girls with ADHD had significantly lower odds of engaging in daily PA and getting enough sleep than boys with ADHD. Children who were obese, poor, or with more severe ADHD had lower odds of sports participation. When adjusting for multiple comparisons, some previously statistically significant results, notably those related to sex, race, and medication use, were no longer significant.

Table 1 Measures of Movement Behaviors

Construct	Survey question(s)
Sports participation	During the past 12 mo, was (CHILD'S NAME) on a sport team or did (he/she) take sports lessons after school or on weekends?
Physical activity	During the past week, on how many days did (CHILD'S NAME) exercise, play a sport, or participate in physical activity for at least 20 min that made (him/her) sweat and breathe hard?
Sleep	During the past week, on how many nights did (CHILD'S NAME) get enough sleep for a child (his/her) age?
Screen time	On an average weekday, about how much time does (CHILD'S NAME) usually spend in front of a television watching television programs, videos, or playing video games? On an average weekday, about how much time does (CHILD'S NAME) usually spend with computers, cell phones, handheld video games, and other electronic devices, doing things other than schoolwork?

Table 2 Demographic and Health Characteristics

Characteristic (unweighted n)	Children with ADHD (n = 4267)	Children with ASD (n = 540)	Children with asthma (n = 5179)	Children with none of the 3 conditions (n = 47,532)
Demographics				
Sex, female	33.6	19.4	49.9	52.4
Age, mean (SE)	11.9 (0.1)	11.0 (0.3)	11.3 (0.1)	11.4 (0.04)
Race				
White only	74.6	70.0	53.5	67.1
Black only	14.1	11.1	27.0	13.6
Other	11.3	19.0	19.5	19.3
Ethnicity, Hispanic	13.5	19.9	19.0	23.5
Primary household language is English	97.3	94.6	91.8	83.7
Maternal education				
Less than high school	11.0	6.0	11.8	14.6
High school graduate	24.9	15.8	22.7	21.1
More than high school	63.9	78.1	65.2	63.6
Free/reduced lunch	66.6	52.4	67.7	59.6
Health				
Condition severity				
Mild	44.2	51.5	75.3	N/A
Moderate	43.9	31.5	20.7	N/A
Severe	11.6	16.9	3.9	N/A
Body mass index				
Underweight (<5th percentile)	5.9	6.4	5.0	6.1
Healthy weight (5th–84th percentile)	61.7	54.2	59.2	64.3
Overweight (≥85th–94th) percentile/obese (≥95th percentile)	32.4	39.4	35.9	29.6
Current ADHD medication use	70.3	N/A	N/A	N/A

Abbreviations: ADHD, attention deficit hyperactivity disorder; ASD, autism spectrum disorder; N/A, not applicable. Note: All results are weighted percentages unless otherwise noted.

Table 5 highlights the covariate-adjusted odds of children with ADHD participating in the various movement behaviors compared with children in the other 3 groups. Children with ADHD had half the odds of sports participation compared with children with asthma and 7 times the odds of sports participation compared with children with ASD. When compared with the normative group, children with ADHD had statistically significant lower odds (odds ratio = 0.3; 95% confidence interval, 0.1–1.0) of obtaining enough sleep every day. There were no changes to the results after adjusting for multiple comparisons.

Discussion

Children with ADHD did not, on average, engage in recommended amounts of PA, sleep, and screen time. In particular, children with ADHD who were older, poor, obese, or more severely affected had lower odds of engaging optimally in certain movement behaviors. This study found that although children with ADHD were 7 times more likely to participate in sports than children with ASD, they had half the odds of sports participation compared with similar age peers with asthma. These findings are consistent with previous studies that found that children with ADHD are at high risk for insufficient PA, excessive sedentary behaviors, and increased risk of obesity.[5,8] The present study extends findings by utilizing more recent data that coincided with the marked increase in use of smart phones and Internet access in US families. In addition, this study compares the health behaviors of youth with ADHD with those with other disorders that have the potential to impair PA, including another neurodevelopmental disorder (ASD) and a common chronic pediatric medical condition (asthma). As children with ADHD are at high risk for obesity and poor health, supporting healthy movement behaviors in this group has the potential to promote executive functioning, general health, and well-being.[4]

Only half of children with ADHD reported participating in sports in the previous year. Children with more severe ADHD and lower socioeconomic status had lower odds of sports participation, which is concerning as these children are also at higher risk for psychiatric comorbidities and health disparities. These groups of children likely face additional barriers to accessing sports opportunities, including cost and difficulties in finding programs that can support children with behavioral challenges. Interestingly, despite low sports participation, children with severe ADHD or low SES were not found to be at lower odds for daily PA. It could be that these children are engaging in nonsport PA (at or outside of school), which may have an appropriate strategy to assuring they

Table 3 Movement Behaviors by Condition

Movement behaviors (unweighted n)	Children with ADHD (n = 4267)	Children with ASD (n = 540)	Children with asthma (n = 5179)	Children with none of the 3 conditions (n = 47,532)
Sports in last 12 mo	48.8	29.3	59.1	59.1
Other clubs/organizations	53.8	45.6	60.3	58.0
No. of days with physical activity, mean (SE)	4.5 (0.1)	3.5 (0.3)	4.4 (0.1)	4.4 (0.03)
No. of days per week with 20 min of physical activity				
0 d	10.8	22.9	9.6	8.7
1–3 d	22.4	25.1	23.3	25.7
4–6 d	33.3	31.3	40.0	38.1
Everyday	33.5	20.7	27.1	27.6
No. of nights with enough sleep, mean (SE)	5.6 (0.1)	5.8 (0.2)	5.9 (0.1)	6.0 (0.02)
Weekday television, mean (SE), h	2.1 (0.1)	1.8 (0.1)	1.9 (0.1)	1.8 (0.02)
Weekday computer/other device, mean (SE), h	1.7 (0.1)	1.3 (0.1)	1.7 (0.1)	1.5 (0.02)
Parent limits screen time	83.5	79.9	81.1	81.3
Parent monitors screen content	94.7	93.5	94.5	92.8
Television in child's bedroom	58.9	49.0	62.2	54.0

Abbreviations: ADHD, attention deficit hyperactivity disorder; ASD, autism spectrum disorder. Note: All results are weighted percentages unless otherwise noted.

are engaging in sufficient PA. Alternatively, given that parent-reported PA is subject to reporting, recall, and social desirability biases and that the question only asked about 20 minutes per day versus the recommended 60 minutes per day, it is likely that fewer children are actually meeting recommendations. Regardless, having school-based and community resources for PA that are inclusive of children with ADHD could help with disparities in access. Of note, obese children with ADHD had lower odds of both sports participation and daily PA, highlighting them as a group in need of additional support and resources for leading active lifestyles.

In the entire sample, a third of children engaged in PA on less than 4 days per week. Such findings highlight the need to promote PA in all children, but especially those with chronic health conditions. Although children with ADHD had 7 times greater odds of sports participation than children with ASD, they had 50% lower odds than children with asthma. Although children with ASD face unique challenges to full participation in PA and sports, specific strategies should focus on promoting PA for this population. Children with ADHD and asthma arguably should be able to achieve full participation with adequate management. It is striking that a behavioral condition such as ADHD appears to be a greater barrier to sports participation than a physical health condition and indicates that there may be undertreatment of ADHD behaviors that interfere with group participation, especially in key high-risk groups.

Children with ADHD were also found to have high amounts of screen time. This finding was noted despite high rates of parents reporting screen time limits and monitoring of screen time content. Previous studies have identified problematic video game use in children with ADHD, including them being less likely than controls to stop playing of their own accord.[33,34] As children with ADHD are often not compliant with parental requests, parents of them may have difficulty in limiting and/or monitoring screen time. Also, although the American Academy of Pediatrics recommends media-free bedrooms,[35] more than half of children with ADHD were reported to have televisions in their bedroom. Given the increasing ubiquity of handheld digital devices in recent years, this question asking about televisions is likely underestimating the prevalence of access to screen devices in bedrooms. Also concerning, screen time may displace PA, sports participation, and other healthy behaviors that are beneficial for the development of social skills and self-esteem.[10] As of yet, there has been little effort to establish structured intervention strategies to help parents limit screen time in their children with ADHD.

Children with ADHD displayed fewer nights with adequate sleep compared with the normative group. Children with neurodevelopmental disorders, including ADHD, are at increased risk for sleep disturbances[36] and would benefit from interventions to promote healthier sleep behaviors.[37] Such treatments may have particular benefit given that inadequate sleep adversely affects self-regulation, irritability, and executive functions that are impaired for children with ADHD, and these impairments are reversed with adequate sleep duration.[38] Furthermore, some children could dually benefit from strategies that focus on decreasing problematic media use (ie, screens in bedrooms, late night screen time) to also improve sleep, as studies have documented associations between problematic screen use and sleep problems.[39,40]

There are some limitations to this study that should be considered. This study was based on parent-reported information (including their child's diagnosis of ADHD, ASD, or asthma) and therefore may be subject to recall and social desirability biases. However, 70% of the ADHD sample were taking stimulant medications, indicating that most children had been medically evaluated. As not all children with ADHD are diagnosed, the obtained results are a conservative test of those whose parents identified their

Table 4 Odds Ratios for Factors Associated With Movement Behaviors Among Children With ADHD

	Sports in last 12 mo	Physical activity everyday	Enough sleep everyday	Weekday screen time <2 h	Television in child's bedroom
Demographics					
Age (continuous)	0.99	0.84**	0.90**	0.83**	1.12**
Sex					
Male	Ref	Ref	Ref	Ref	Ref
Female	0.81	0.65*	0.72*	1.02	0.99
Race/ethnicity					
Non-Hispanic, white	Ref	Ref	Ref	Ref	Ref
Non-Hispanic, black	0.61*	1.06	0.62	0.77	2.45**
Hispanic	0.93	1.21	0.88	0.65	1.13
Multiracial	1.39*	1.20	0.94	0.95	0.94
English primary language					
Yes	Ref	Ref	Ref	Ref	Ref
No	0.40	0.67	4.54**	0.30*	1.37
Free/reduced lunch					
Yes	0.44**	2.07**	1.66*	0.96	1.03
No	Ref	Ref	Ref	Ref	Ref
Health					
Condition severity					
Mild	Ref	Ref	Ref	Ref	Ref
Moderate	0.72	1.13	0.74	1.35	0.75
Severe	0.43**	1.31	1.02	1.80	0.66
Body mass index					
Underweight (<5th percentile)	0.85	2.19*	1.14	0.89	0.55
Healthy weight (5th–84th percentile)	Ref	Ref	Ref	Ref	Ref
Overweight (≥85th–94th percentile)	0.65	1.26	1.01	1.02	0.82
Obese (≥95th percentile)	0.50*	0.62**	0.75	0.59	1.17
ADHD medication use					
Yes	0.99	0.93	0.95	1.48*	0.70*
No	Ref	Ref	Ref	Ref	Ref

Abbreviations: ADHD, attention deficit hyperactivity disorder; Ref, reference.
*Unadjusted $P < .05$.
**Unadjusted and false discovery rate adjusted $P < .05$.

Table 5 Adjusted Odds of Movement Behaviors in Children With ADHD Compared With Children With ASD, Asthma, and Normative Group

	OR (95% CI)		
Health behaviors	ADHD compared with ASD	ADHD compared with asthma	ADHD compared with normative group
Sports in last 12 mo	7.1 (2.6–19.5)*	0.5 (0.3–0.8)*	0.6 (0.2–1.7)
PA everyday	3.1 (1.2–8.1)	1.5 (1.0–2.4)	2.8 (0.9–8.3)
Enough sleep every day	0.6 (0.2–1.5)	0.8 (0.5–1.3)	0.3 (0.1–1.0)*
Weekday screen time <2 h	0.3 (0.1–1.0)	0.7 (0.4–1.1)	1.0 (0.3–4.2)
Television in child's bedroom, n (%)	1.8 (0.7–4.7)	1.1 (0.7–1.7)	0.7 (0.2–2.2)

Abbreviations: ADHD, attention deficit hyperactivity disorder; ASD, autism spectrum disorder; CI, confidence interval; OR, odds ratio. Note: Adjusted for age, sex, race/ethnicity, Socioeconomic status (using free/reduced lunch eligibility), condition severity, overweight/obese status, and current ADHD medication use.
*$P < .05$.

child with ADHD, and there may be important socioeconomic or other differences between children who are diagnosed and those who are not. Replication is needed where diagnoses are confirmed. Furthermore, it is likely that our analyses overestimate positive health behaviors and underestimate negative ones. Arguably, the question about sports participation may have more face validity

than questions about amounts of PA, sleep, or screen time. Body mass index was also calculated based on parent reported weight and height, which has considerable limitations.[41] Also, the way we categorized the 4 groups does not account for children who may have more than 1 condition. This also means that children in the "normative" group may have other conditions besides ADHD, ASD, and asthma. Other unmeasured factors may exist that are unaccounted for in our analyses. However, the large sample size and complex sampling frame meant to capture a nationally representative group strengthen our conclusions and make the data more generalizable.

Longitudinal studies with information on medication formulation and dosing are needed to evaluate whether children with ADHD may be more likely to participate in sports when effectively treated, including beyond the school day to include times when sports participation is possible.[5] In addition, evidence-based behavioral treatments may also reduce barriers to sports and PA participation and provide families with strategies to better manage problematic screen and sleep behaviors. There may also be a systemic need to establish and study sports programs with structure to create successful experiences for children with ADHD and to explore interventions with other PA formats (eg, individual physical activities, family routines involving PA, activity/fitness trackers[42]).

Despite their strong association with ADHD, quality of life, and functioning, health behaviors are not regularly assessed or addressed during the routine evaluation and treatment of ADHD.[43] This study presents a compelling argument for the continued examination of movement behavior interventions as a prevention or intervention or augmentation strategy for ADHD[44] due to the clear benefits increasing positive health behaviors, and the increased risk for poor outcomes in children with ADHD. In addition, suboptimal PA, high screen time, and inadequate sleep may co-occur in many children with ADHD. Interventions to support multiple healthy movement behaviors for children with ADHD have the potential for long-term benefits in this high-risk population.

Conclusion

Children with ADHD exhibit suboptimal movement behaviors related to sports participation, sleep, and screen time that may contribute to long-term health risks associated with ADHD. These domains represent novel treatment targets to support health and functioning in children with ADHD.

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