Article

Children With ADHD Engage in Less Physical Activity

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Abstract

Background: Children with ADHD should engage in physical activity, given its known role as a treatment adjunct. **Objective:** The main objective of this study is to assess the relationship between ADHD diagnosis and physical activity among children in the United States. **Methods:** This retrospective population-based cross-sectional study used data from the 2016 caregiver reported, National Survey of Children's Health (NSCH). **Results:** In the adjusted binary model, children with an ADHD diagnosis had 21% lower odds of engaging in daily physical activity than their nondiagnosed counterparts. In the adjusted multinomial model, children with ADHD were increasingly unlikely to report additional days of physical activity as compared to those without a diagnosis. **Conclusion:** Given the known benefits of physical activity for those with ADHD, this study underscores the need for enhanced access to an important treatment adjunct for this population. *(J. of Att. Dis. XXXX; XX(X) XX-XX)*

Keywords

ADD/ADHD, children, exercise, epidemiology

Introduction

ADHD is the most common neuropsychiatric disorder affecting 5% to 10% of children worldwide, with most children being diagnosed between 5 and 10 years of age (Faraone, Sergeant, Gillberg, & Biederman, 2003; Froehlich et al., 2007; Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007). According to the 2016 National Survey of Children's Health (NSCH), an estimated 5.4 million children in the United States currently have ADHD, while an additional 700,000 children have carried this diagnosis during their lifetime (Danielson et al., 2018). Previous studies have demonstrated that an ADHD diagnosis is associated with lower health-related quality of life (HRQL) scores (Klassen, Miller, & Fine, 2004), including decreased academic performance, disrupted sleep patterns, and mental health problems that persist into adulthood.

Diagnosing and treating ADHD requires an interdisciplinary approach. Recent literature highlights an inverse association between ADHD and several health behaviors including diet, physical activity, and sports participation (Ahn, Min, & Kim, 2017; Suchert, Pedersen, Hanewinkel, & Isensee, 2017; Wu, Ohinmaa, & Veugelers, 2016). This literature also identifies a link between ADHD and an increased odds of screen time, obesity, depression, and overeating. Using prior NSCH data, Kim, Mutyala, Agiovlasitis, and Fernhall (2011) examined ADHD and overall health-related behaviors and found that children with ADHD reported decreased participation in physical activity and organized sports, while Cook, Li, and Heinrich (2015) found that children with ADHD and learning disabilities were more likely to be obese and that children with either of these diagnoses were less likely to meet recommended levels of physical activity. Pursuant to this, multiple studies demonstrate that regular physical activity is a beneficial adjunct therapy for children with ADHD (Berwid & Halperin, 2012; Best, 2010; Cerrillo-Urbina et al., 2015; Halperin, Berwid, & O'Neill, 2014; Ng, Ho, Chan, Yong, & Yeo, 2017; Silva et al., 2015), citing improvements in core symptoms (hyperactivity and impulsivity), associated symptoms (anxiety, executive function, and social disorders), neurocognitive testing scores, and sleep. However, there is limited literature assessing the *degree* of physical activity performed by ADHD children, and those studies examining therapeutic benefits are limited by small study samples, with most having less than 50 participants (Ng et al., 2017; Schoenfelder, Moreno, Wilner, Whitlock, & Mendoza, 2017; Ziereis & Jansen, 2015).

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Our study aimed to assess the engagement in physical activity through 6- to 17-year-old children with an ADHD diagnosis. This study also examined the relationship between physical activity and ADHD symptom severity. Given known benefits of physical activity in ADHD, we hypothesized that children with attention deficit disorder (ADD)/ADHD would be more likely to meet the American Academy of Pediatrics' (AAP) standard (AAP, 2015) of 60 minutes of daily physical activity, compared to those without a diagnosis.

Methods

This retrospective cross-sectional study used data from the 2016 NSCH. Conducted by the U.S. Census Bureau, this is a nationally representative parent/caregiver-reported survey which provided information on multiple aspects of a selected child's health from a household ($N = 50,212$ for 2016 data). The survey was conducted in English and Spanish languages. For the purpose of this study, 6- to 17-year-old children were included ($N = 34,972$) because the NSCH does not collect exercise information for younger children. The final study population ($N = 34,675$) was determined based on complete information for ADHD diagnosis and physical activity (97% of the eligible children). This study was considered institutional review board (IRB) exempt because it uses a de-identified, publicly available data set and is not considered human participants research.

Exposure and Outcome

The primary exposure was an ADHD diagnosis based on the following question: "Has a doctor or other health care provider EVER told you that [your child] has . . . Attention Deficit Disorder or Attention-Deficit/Hyperactivity Disorder, that is, ADD or ADHD?" In our study, this exposure was termed "ADHD." An additional question inquired about severity of the child's ADHD symptoms—"If yes, is [your child's ADD/ADHD] Mild, Moderate, or Severe?." Responses to this question were coded as three ADHD symptoms categories: mild, moderate, and severe.

Measurement of physical activity was the primary outcome. It was assessed using the following question: "During the past week, on how many days did [your child] exercise, play a sport, or participate in physical activity for at least 60 minutes?" The AAP recommends that *all* children engage in at least 60 minutes of physical activity every day (AAP, 2015). To assess adherence to the AAP physical activity recommendation, a binary outcome variable was created: daily physical activity (7 days per week) versus nondaily physical activity (0-6 days per week). In addition, to assess degree of physical activity, a four-category variable defining days of physical activity was created: 0 days per week, 1 to 3 days per week, 4 to 6 days per week, and daily physical activity.

Covariates

Age was categorized as 6 to 11 and 12 to 17 years of age. Assigned sex was reported as male or female. Race was based on caregiver report and categorized in the NSCH database as White alone, Black or African American alone, and Other. Primary language of the household was recorded as English, Spanish, and Other. Highest level of adult education for the respondent was determined using the question, "What is the highest grade or year of school you have completed?"; responses were categorized as "less than high school," "high school graduate," "some college/technical school," and "college degree and above."

Poverty status was defined as $<200\%$, 201% to 400%, and $>400\%$ of the Department of Health and Human Services (DDHS) definition of "poverty level" based on income and household size (U.S. DDHS, 2019). Neighborhood safety was assessed with the NSCH survey question "To what extent do you agree with these statements about your neighborhood or community? This child is safe in our neighborhood"—respondents were able to select "strongly agree" "somewhat agree," "somewhat disagree," and "strongly disagree." Responses were grouped into a binary categorical variable—"agree" responses indicating safe, and "disagree" responses indicating unsafe.

Finally, digital media exposure (DME) was assessed by combining two questions: "ON AN AVERAGE WEEKDAY, about how much time does (fill with SC_NAME) usually spend in front of a TV watching TV programs, videos, or playing video games?" and "ON AN AVERAGE WEEKDAY, about how much time does (fill with SC_NAME) usually spend with computers, cell phones, handheld video games, and other electronic devices, doing things other than schoolwork?." Parents could report up to 8 hours for each activity. A new variable "DME" was created, which represented the sum of reported hours for both questions and then a binary variable was created with the following options: <1 hour of DME per day and ≥ 1 hour of DME per day. The 1-hour cutoff was set to reflect updated recommendations by the AAP (2016).

Statistical Analyses

All analyses were performed accounting for weighting and complex survey design of NSCH to represent the population of noninstitutionalized children aged 0 to 17 who live in housing units in the 50 U.S. states and the District of Columbia. First, we assessed the distribution of physical activity and covariates by ADHD diagnosis status. We then used binary and multinomial logistic regression to assess the unadjusted and adjusted association between ADHD diagnosis and physical activity. We also conducted a secondary analysis among children with diagnosed ADHD to

Table 1. Demographics Based on ADHD Diagnosis for Children 6 to 17 Years: National Survey of Children's Health, 2016 (N = 34,675).

	ADD/ADHD diagnosis (n = 4,499) number (weighted %)	No diagnosis (n = 30,176) number (weighted %)	p value χ^2
Physical activity >60 minutes (days per week)			<.001
0 days	580 (14.3)	2,204 (8.2)	
1-3 days	1,801 (37.5)	11,274 (38.5)	
4-6 days	1,210 (26.0)	10,097 (28.9)	
7 days	908 (22.2)	6,601 (24.4)	
Age category (years)			<.001
6-11	1,627 (41.4)	12,952 (51.2)	
12-17	2,872 (58.6)	17,224 (48.8)	
Assigned sex			<.001
Male	3,093 (70.2)	14,623 (48.8)	
Female	1,406 (29.8)	15,553 (51.2)	
Race			<.001
White	3,632 (69.7)	23,396 (67.7)	
Black	324 (16.9)	1,838 (13.7)	
Other	543 (13.4)	4,942 (18.6)	
Primary household language			<.001
English	4,376 (95.7)	28,042 (83.8)	
Spanish	58 (2.9)	884 (10.5)	
Other	36 (0.6)	1,010 (4.3)	
Missing	29 (<1.0)	240 (1.5)	
Poverty status			.1470
At/below 200%	1,416 (46.9)	7,475 (44.1)	
200%-400%	1,311 (23.9)	9,173 (26.0)	
Above 400%	1,772 (29.2)	13,528 (29.9)	
Safe neighborhood			.8197
Yes	4,218 (91.1)	28,824 (91.7)	
No	200 (6.3)	844 (6.1)	
Missing	81 (2.6)	508 (2.2)	
Digital media exposure			<.001
≥1 hour	3,851 (85.6)	24,473 (81.1)	
<1 hour	612 (14.3)	5,822 (18.9)	
Highest level of Adult education			<.001
Less than high school	104 (6.6)	677 (9.9)	
High School/GED	656 (20.9)	3,830 (19.9)	
Some college/tech school	1,236 (26.9)	6,668 (21.4)	
College degree and above	2,391 (42)	18,375 (45.9)	
Missing	112 (3.6)	626 (2.9)	

Note. ADD = attention deficit disorder.

assess the association of severity of ADHD and physical activity. Missing data in multiple logistic regression can affect the power of a study, though only 3% of the observations in the study were excluded from the multivariable analyses. Multivariable models controlled for assigned sex, age, poverty status, DME, and highest level of adult education. All analyses were performed using STATA statistical software with survey suite of commands, version 14.2 for Macintosh (StataCorp, 2015).

Results

Among U.S. children ages 6 to 17 years, 11.7% were reported to carry a lifetime diagnosis of ADHD. A larger proportion of children with ADHD (14.3%) reported 0 days of physical activity per week compared to those without a diagnosis (8.2%, $p < .001$, Table 1), while the proportion of children reporting daily physical activity was more similar—22.2% of those with ADHD and 24.4% of those without a diagnosis (Table 1). When

Table 2. Unadjusted and Adjusted Odds Ratios (aOR)[a] of Daily Physical Activity[b] for U.S. Children Aged 6 to 17 Years: National Survey of Children's Health, 2016, (N = 33,435).

Characteristics	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
ADHD		
Diagnosis	0.88 [0.76, 1.02]	0.79 [0.67, 0.93]
No diagnosis (ref)		
Sex		
Female	0.63 [0.56, 0.72]	0.58 [0.51, 0.66]
Male (ref)		
Age (years)		
6-11 (ref)		
12-17	0.54 [0.48, 0.61]	0.58 [0.51, 0.64]
Race		
Black	1.12 [0.94, 1.36]	1.06 [0.88, 1.29]
Other	0.92 [0.77, 1.10]	0.94 [0.77, 1.15]
White (ref)		
Poverty status (% of FPL)		
<200	1.39 [1.28, 1.59]	1.38 [1.20, 1.60]
200-400	1.07 [0.94, 1.22]	1.02 [0.89, 1.16]
>400 (ref)		
Primary household language		
Spanish	0.74 [0.53, 1.04]	0.64 [0.45, 0.91]
Other	0.62 [0.45, 0.84]	0.54 [0.39, 0.75]
English (ref)		
Digital media exposure		
≥1 hour	0.65 [0.57, 0.74]	0.69 [0.60, 0.80]
<1 hour (ref)		
Highest level of adult education		
Less than high school	1.05 [0.77, 1.45]	1.15 [0.82, 1.63]
High school	1.28 [1.08, 1.50]	1.20 [1.00, 1.43]
Some college/tech school	1.24 [1.08, 1.42]	1.18 [1.01, 1.36]
College degree and above (ref)		

Note. OR = odds ratio; CI = confidence interval; FPL = federal poverty level.
[a]Adjusted for assigned sex, age, race, poverty status, digital media exposure, and highest level of adult education.
[b]Binomial variable of daily (7 days per week) versus nondaily (0-6 days per week) physical activity.

physical activity was divided into two categories (daily versus nondaily) to reflect the AAP recommendation, children with an ADHD diagnosis had 21% lower adjusted odds ratio (aOR) of engaging in daily physical activity than their nondiagnosed counterparts (aOR 0.79; 95% CI 0.67-0.93; Table 2). In addition, the graded model demonstrated significant inverse relationship between ADHD diagnosis and days of physical activity per week; children with ADHD were increasingly unlikely to report additional days of exercise when compared to those without an ADHD diagnosis, with 0.56 odds (95% CI 0.44-0.69) for 1 to 3 days, 0.47 odds (95% CI 0.37-0.60) for 4 to 6 days, and 0.44 odds (95% CI 0.34-0.57) for 7 days of physical activity, compared to 0 days per week of physical activity (Table 3).

The following covariates were found to be independent risk factors of not achieving daily physical activity: female sex, age 12 to 17 years, and increased digital medical exposure (>1 hour per day; Table 2). Female sex and 12- to 17-year olds were also increasingly unlikely to report additional days of exercise in the graded model (Table 3). Lower parental education status and non-English household language were associated with decreased odds of physical activity only in the graded model. For example, children of parents reporting "less than high school" education had 0.53 odds (95% CI 0.34-0.83) of engaging in 1 to 3 days, 0.52 odds (95% CI 0.32-0.86) of 4 to 6 days, and 0.65 odds (95% CI 0.40-1.05) of 7 days of physical activity per week, respectively, compared to 0 days per week. Patients reporting Spanish or other household language demonstrated significantly decreased odds of reporting 4 to 6 days or daily physical activity.

Assessment of ADHD symptom severity demonstrated a decrease in the odds of physical activity only among those

Table 3. Adjusted Odds Ratios (aOR)[a] of Weekly Physical Activity for U.S. Children Aged 6 to 17 Years: National Survey of Children's Health, 2016, (*N* = 33,435).

Characteristics	1-3 days per week[b]	4-6 days per week[b]	7 days per week[b]
ADHD			
Diagnosis	0.55 [0.44, 0.69]	0.47 [0.37, 0.60]	0.44 [0.34, 0.57]
No diagnosis (ref)			
Sex			
Female	0.86 [0.70, 1.06]	0.71 [0.57, 0.87]	0.50 [0.19, 0.32]
Male (ref)			
Age (years)			
12-17	0.42 [0.33, 0.53]	0.36 [0.28, 0.46]	0.25 [0.19, 0.32]
6-11 (ref)			
Race			
Black	0.64 [0.49, 0.85]	0.43 [0.32, 0.59]	0.63 [0.46, 0.86]
Other	1.18 [0.88, 1.56]	0.90 [0.67, 1.20]	0.99 [0.71, 1.36]
White (ref)			
Poverty status (% of FPL)			
<200	0.89 [0.68, 1.15]	0.81 [0.62, 1.07]	1.18 [0.90, 1.56]
200-400	1.09 [0.87, 1.37]	1.00 [0.79, 1.25]	1.05 [0.83, 1.34]
>400 (ref)			
Primary household language			
Spanish	0.78 [0.51, 1.21]	0.42 [0.25, 0.69]	0.43 [0.26, 0.72]
Other	0.74 [0.46, 1.20]	0.48 [0.29, 0.80]	0.36 [0.22, 0.60]
English (ref)			
Digital media exposure			
≥1 hour	0.72 [0.47, 1.10]	0.52 [0.34, 0.79]	0.44 [0.28, 0.67]
<1 hour (ref)			
Highest level of adult education			
Less than high school	0.54 [0.35, 0.83]	0.40 [0.25, 0.64]	0.48 [0.30, 0.77]
High school	0.74 [0.56, 0.98]	0.44 [0.33, 0.59]	0.72 [0.53, 0.98]
Some college/tech school	0.85 [0.67, 1.07]	0.68 [0.53, 0.86]	0.93 [0.72, 1.20]
College degree and above (ref)			

Note. OR = odds ratio; FPL = federal poverty level.
[a]Adjusted for assigned sex, age, race, poverty status, digital media exposure, and highest level of adult education.
[b]Reference: 0 days per week.

Table 4. Adjusted Odds Ratio (aOR)[a] of Weekly Physical Activity Among Children With ADHD, by Symptom Severity: NSCH, 2016, (*N* =4,219).

ADHD symptoms	1-3 days per week[b]	4-6 days per week[b]	7 days per week[b]
Mild (*n* = 1,874)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Moderate (*n* = 1,872)	0.54 [0.36, 0.81]	0.46 [0.30, 0.73]	0.48 [0.30, 0.75]
Severe (*n* = 473)	0.74 [0.40, 1.39]	0.41 [0.21, 0.83]	0.95 [0.47, 1.91]

Note. OR = odds ratio; NSCH = National Survey of Children's Health.
[a]Adjusted for assigned sex, age, race, poverty status, digital media exposure, and highest level of adult education.
[b]Reference: 0 days per week.

reporting moderate symptoms (Table 4). As compared to those with mild symptoms, children with moderate symptoms had 0.54 odds (95% CI 0.36-0.81) of engaging in 1 to 3 days, 0.46 odds (95% CI 0.30-0.72) of engaging in 4 to 6 days, and 0.49 odds (95% CI 0.31-0.77) of engaging in daily physical activity, compared to 0 days per week. Those children with severe symptoms did not demonstrate the same graded, inverse relationship. The only significant relationship for these children included 0.41 odds (95% CI 0.20-0.83) of 4 to 6 days of physical activity per week, compared to 0 days.

Discussion

This population-based study demonstrates that children with ADHD were less likely to meet the AAP's physical activity recommendation compared to those without a diagnosis. Beyond the AAP criteria, ADHD children were also less likely to engage in *additional* days of physical activity in a given week. Given the known benefits of exercise in ADHD children including improvements in core ADHD symptoms (Cerrillo-Urbina et al., 2015), standardized testing (Best, 2010), sleep (Grunwald & Schlarb, 2017), mood (Cerrillo-Urbina et al., 2015; Janssen & LeBlanc, 2010), and social disorders, these findings underscore the need for health care providers to enhance this resource for ADHD children.

In our study, female gender was determined to be independently associated with decreased physical activity regardless of ADHD diagnosis. This may be a reflection of a long-standing knowledge of evolving gender disparities in physical activity (Solmon, 2014), as well as recent studies examining ADHD and health-related behaviors (Cook et al., 2015; Kim et al., 2011). Given these findings, girls appear to be at higher risk of physical inactivity, and those with ADHD should receive gender-informed care and resources.

Covariate analysis highlighted additional groups of children at particular risk of not achieving AAP recommendations, regardless of ADHD status. First, low educational attainment and non-English speaking households were associated with decreased odds of physical activity. Health disparities research has repeatedly demonstrated that minority, non-English speaking families are less likely to receive an ADHD diagnosis than their White English-speaking counterparts (Morgan, Hillemeier, Farkas, & Maczuga, 2014; Morgan, Staff, Hillemeier, Farkas, & Maczuga, 2013). Our data demonstrated that fewer, primarily Spanish-speaking individuals reported an ADHD diagnosis for their children compared to primarily English-speaking households. Underrepresentation of minorities in the exposed group highlights the impact of linguistic and cultural barriers to ADHD diagnosis and resource provision. Our results also support the established relationship between increased DME and decreased physical activity. Finally, approximately 6% of our population reported unsafe neighborhoods. These risk factors echo the findings of prior health initiatives, which report several barriers to regular physical activity in all children, including increased DME (Robinson et al., 2017), unsafe neighborhoods, weather/environment, lack of time, independent mobility, inherent capability/fitness, and motivation (AAP, 2011). A clinician can address these risk factors through interventions such as counseling to set limits on DME, connecting parents to adult education, culturally informed discussions around health and exercise, ensuring interpreter services, and creation of—or connection to, safe neighborhood play areas (Carver, Timperio, & Crawford, 2008). In this way, clinicians can not only educate families about the importance of regular physical activity but can also educate how to facilitate it in their home environment.

So, what about physical activity in school settings? Given limitations in the home setting, many families may rely on the school to provide adequate physical activity for their children. Recent reports indicate that physical activity programs in schools are often being cut (Committee on Physical Education and Physical Activity in the School Environment, 2013), despite research demonstrating the benefits of *school*-based physical activity (Mura, Vellante, Nardi, Machado, & Carta, 2015). These barriers are compounded in children with ADHD, who have been shown to have a low tolerance for frustration, restlessness, and impairments in executive functioning (Choudhry et al., 2013; Silva et al., 2015; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). Together, these challenges may make it more difficult for ADHD children to leverage their school as a source of regular physical activity. Clinicians should work with families and schools to advocate against the loss of school-based physical activity programs and even try to enhance them for children with ADHD.

Finally, our study identified an association between ADHD symptom severity and decreased physical activity, with individuals reporting *moderate* symptoms being the least likely to engage in physical activity as compared to those with mild or severe symptoms. These findings are difficult to interpret, given the complexity of ADHD diagnosis and parental reporting limitations. Additional research is needed to further evaluate the impact of symptom severity on the medical management of, and provision of resources for, ADHD children.

This study has limitations similar to other works using large, national data sets. Several limitations stem from the exposure assessment (ADHD). ADHD diagnosis is complex and requires an interdisciplinary approach, including reports across multiple settings from parents, caregivers, and teachers. Children must undergo formal assessment and fulfill certain criteria in the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*; American Psychiatric Association [APA], 1994) or *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM-5*; APA, 2013). Concurrent mental health disorders may also manifest or exacerbate symptoms associated with ADHD, resulting in a child erroneously meeting ADHD criteria. Clinicians may also use "more relaxed" criteria than required by the *DSM-IV* due to a child's functional impairment or need for associated services (Song, Dieckmann, & Nigg, 2019). In our study, ADHD status was ultimately determined by parental response, though the survey question did require a physician's diagnosis. ADHD severity assessment was also based on parents' self-report, which is limited by parents' understanding of the spectrum of ADHD

and its associated symptoms. However, survey-based studies such as ours will remain limited in an objective assessment of ADHD severity. A final limitation involves recall bias by the respondent, though recent literature indicates that primary caregivers are fairly accurate reporters of ADHD diagnosis (Visser, Danielson, Bitsko, Perou, & Blumberg, 2013). The overall prevalence for ADHD diagnosis (11.7%) in our study is slightly above to the worldwide prevalence of ADHD of 5% to 10% (Faraone et al., 2003), but similar to that reported in the United States (10.4%) (U.S. DDHS, 2017).

In spite of these limitations, this large population-based study identified that children with ADHD, especially girls, are less likely to engage in physical activity than their nondiagnosed peers. In addition, covariate analysis highlights childhood physical activity as a multifaceted public health issue; factors such as parental education, household language, and DME negatively impact children's odds of achieving the AAP recommendation. Given the known benefits of physical activity in ADHD, this study underscores the need for enhanced education and facilitation of this important treatment adjunct. Health care providers, teachers, and parents can affect change at an individual level by advocating for physical activity in the home and school settings. At a national level, these findings should enable public health policy and decision makers to improve access to regular physical activity among children with ADHD.

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