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Obesity, Physical Activity and Sedentary Behaviors in Children with an Autism Spectrum Disorder

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Abstract *Background and Objectives* Previous literature using small sample sizes and limited geographic areas report that overweight/obesity and physical inactivity occur at higher rates among children with autism spectrum disorder (ASD) compared to typically developing peers. The purpose of this study was to examine obesity, overweight, physical activity, and sedentary behavior among children and youth with and without ASD using nationally representative data and controlling for secondary conditions, including intellectual and learning disabilities, ADHD, developmental delay, and other mental, physical, and medical conditions, as well as medication use. *Methods* Data were collected from the 2011–2012 National Survey of Children's Health, a cross-sectional survey of 65,680 (weighted N = 49,586,134) children aged 6–17 (1385 with ASD, weighted N = 986,352). Logistic regression was used to estimate odds ratios, adjusting for demographics and possible secondary conditions. *Results* Having a diagnosis of ASD was associated with higher odds of obesity (OR 1.76, CI 1.27–2.43; $p = <0.001$). However, after additional adjustment for possible secondary conditions, ASD diagnosis was no longer associated with obesity. Those with moderate ASD (OR 0.58, CI 0.36–0.93; $p = <0.05$) reported lower odds of sedentary behavior, but this association failed to achieve significance after adjustment for secondary conditions and medication use. No significant associations between ASD and overweight or physical activity were found. *Conclusions* These findings suggest that ASD diagnosis is not significantly associated with obesity status after adjustment for possible secondary conditions and medication use. Decision makers, clinicians, and researchers developing interventions for children with ASDs should consider how secondary conditions may impact obesity and related activities.

Keywords Autism spectrum disorder · Learning disability · Physical activity · Sedentary behavior · Obesity · Medication use

Significance

This study builds upon previous investigations of the relationship between ASD diagnosis and the outcomes of interest by including an examination of the severity of ASD and its impact on these outcomes, and by controlling for a variety of diagnoses and conditions that may confound the relationship between ASD and each of our outcomes of interest.

Introduction

More than one-third of children and youth in the United States (US) were obese in 2012 [19]. Although experts believe a wide range of contributing factors exist, low rates of physical activity and high rates of sedentary behaviors that may include television, computer, and videogame utilization are prevalent in this population [12]. Previous studies have found that children and youth with autism spectrum disorders (ASD) are at a particularly high risk of being overweight or obese [6, 8, 21]. Furthermore, studies suggest that those

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with ASD engage in sedentary behaviors more frequently, possibly due to social skill impairments, sensory challenges, or secondary conditions, and are more likely to use medications that lead to weight gain [7, 24, 27].

It is well-documented in the literature that young children and adolescents with ASD engage in less physical activity [16] and more sedentary behaviors [17], and are more likely to be obese [7, 27]. However, previous studies have been limited by geographic locations not generalizable to the overall US. Larger, more generalizable, studies have also found that young children and adolescents with ASD have at least the same prevalence of obesity [6]; and adolescents with a myriad of developmental disabilities, including autism, have higher rates of obesity [21]. Notably, both national studies did not examine how ASD is independently associated with obesity when controlling for secondary conditions that may contribute to obesity risk. Moreover, no national study has examined physical activity levels and sedentary behaviors in this context.

The purpose of the current study is to use recently collected nationally representative data to examine several outcomes including obesity/overweight, sedentary behaviors, and physical activity levels among children and youth with and without ASD, as well as by severity of ASD. We build upon previous research by expanding beyond a determination of the presence or absence of an ASD to further examine the severity of ASD and its impact on these outcomes. We believe this is an important contribution given the spectrum of the disorder, whereby the impact of ASD on functioning may vary greatly depending on severity. Importantly, we also control for a variety of diagnoses and conditions that may confound the relationship between ASD and each of our outcomes of interest. These secondary conditions may be commonly diagnosed among children with ASD and may confound the relationship between ASD and each of our outcomes of interest. We propose that these secondary conditions, when accounted for in the analyses, can more fully describe the relationship between ASD and our outcomes of interest and provide more nuanced information to those involved in managing the care of children and adolescents with ASD. Findings from this study will be valuable to policy and decision-makers, educators, and health care providers who are interested in better understanding how obesity/overweight, sedentary behaviors, and physical activity are related to an ASD diagnosis.

Methods

Data Source

Data from the 2011–2012 National Survey of Children's Health (NSCH) were used for the current study. The NSCH is a cross-sectional survey conducted by the Centers for Disease Control and Prevention (CDC) that uses telephone surveys of US households with at least one child aged 0–17 years. Responses are based upon parental report. In total, 95,677 phone surveys were conducted between February 2011 and June 2012 [18]. Data are weighted by the CDC to be representative of non-institutionalized children nationally and within each state and the District of Columbia. Our study was exempted from review by our university institutional review board as the dataset is publicly available and de-identified.

Dependent Variables

Four separate dichotomized outcome variables were examined: obesity, overweight, physical activity, and sedentary behavior. Obesity was defined as a Body Mass Index (BMI) greater than or equal to the 95th percentile of BMI-for-age, and overweight was defined as a BMI from greater than or equal to the 85th percentile to less than the 95th percentile [3]. Physical activity was derived from the NSCH survey question, "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?" Based upon the Physical Activity Guidelines for Americans published by the Department of Health and Human Services recommendation that children and adolescents should have 60 min or more of physical activity each day [5], responses were dichotomized to 0 if the respondent indicated 0–6 days of physical activity and 1 if the response was 7 days. Sedentary behavior was derived from the question, "On an average weekday, about how much time does [CHILD'S NAME] usually spend in front of a TV watching TV programs, videos, or playing video games?" Consistent with American Academy of Pediatrics (AAP) recommendations, this question was dichotomized to 0 if the respondent indicated less than 2 h per day and 1 if the response was greater than or equal to 2 h per day [1].

Independent Variables

The primary independent variables were the presence of an ASD diagnosis, dichotomized to 0 if the respondent indicated "No" and 1 if the response was "Yes", as well as ASD severity. NSCH respondents who indicated that their child currently had ASD were subsequently asked about the severity of their child's ASD. Respondents could self-classify the child's autism as mild, moderate, or severe. Demographic independent variables included gender, race (White/non-White), ethnicity (Hispanic/non-Hispanic), and US Census Region (Northeast, South, Midwest, West). Age categories were also analyzed and dichotomized as children aged 6–11 years or adolescents aged 12–17 years.

In addition, when examining the relationship between autism severity and each of the outcome variables of interest, we included control variables for possible secondary conditions that may be present based on NSCH responses. These secondary conditions could include intellectual disability, attention deficit hyperactivity disorder (ADHD), developmental delay (other than autism), a mental health condition, a physical health condition, a medical condition, or some other condition. "Mental conditions" included depression, anxiety problems, and behavior or conduct problems. "Physical conditions" included cerebral palsy and/or bone, joint, or muscle problems. "Medical conditions" included asthma, diabetes, and epilepsy or seizure disorders. "Other conditions" included brain injury or concussion, speech or other language problems, vision problems that cannot be corrected with standard glasses or contact lenses, hearing problems, and Tourette syndrome. Secondary conditions were combined in this manner as to be clinically meaningful for practitioners in terms of how these conditions are approached and managed. An examination of variance inflation factors and factor analysis of secondary conditions did not suggest a more appropriate approach for the grouping of secondary conditions.

Medication use was derived from the NSCH survey question, "During the past 12 months, has [CHILD'S NAME] taken any medication because of difficulties with (his/her) emotions, concentration, or behavior?" This question was asked only for children who were not taking medication for ADD/ADHD. Responses were dichotomized to 0 if the respondent indicated "No" and 1 if the response was "Yes."

Data Analysis

Analyses were conducted using Stata version 13.1. Consistent with CDC guidance on use of NSCH data to ensure proper calculations of standard errors and to maintain the national representativeness, weights were applied and the Stata subpop procedure was used to restrict analyses to the subpopulation of children aged 6–17 years. In total, 65,680 (weighted N = 49,586,134) children between the ages of 6 and 17 were included in analyses. The cutoff for statistical significance was set at $p < 0.05$.

Descriptive statistics, including frequencies and percentages, were analyzed for all variables. Chi-square analyses examined differences in obesity, overweight, physical activity, and sedentary behavior by ASD diagnosis and severity. Multivariate logistic regression was then used to calculate adjusted odds ratios for each independent variable on each of the four outcome variables. Two models were estimated for each outcome. Model A included ASD diagnosis or severity and demographic variables. Model B included ASD diagnosis or severity and demographic variables, but also added secondary conditions and medication use.

Results

Overall, the total weighted sample included 49,586,134 children aged 6–17. Just over half of respondents were male. Furthermore, approximately half of respondents were under age 12 and half were aged 12–17. Approximately one-third of respondents were non-White, and one-fifth were of Hispanic ethnicity.

An ASD diagnosis was present for approximately 2 % of the sample of all children aged 6–17 and included mild autism (weighted n = 517,797, 1 %), moderate autism (weighted n = 333,287, 0.7 %) and severe autism (weighted n = 135,268, 0.3 %). Overall, in the total sample, approximately 10 % of respondents were obese and an additional 10 % were overweight. Twenty-eight percent of children were reported to have engaged in physical activity for 7 days during the previous week and 47.6 % were deemed sedentary (≥2 h screen time/day), though these categories are not mutually exclusive. Children with an ASD diagnosis were significantly more likely to report the presence of every secondary condition included in our analyses compared to their typically-developing peers. This finding generally held when examining secondary conditions by ASD severity. The presence of all secondary conditions, with the exception of ADHD and medical conditions, differed significantly across ASD severities. The frequency of a diagnosis other than autism ranged from 1.2 % for an intellectual disability to 11.2 % for any medical condition. Of those who reported taking medication unrelated to ADD/ADHD, 3.1 % reported medication usage to address difficulties with emotions, concentration, or behavior (see Table 1).

In Chi-square analyses, there was no relationship between being overweight and having any autism diagnosis (see Table 1); however obesity rates were higher among those with an autism diagnosis compared to those with no autism (obesity rate of 16.4 % among those with an ASD diagnosis compared to 9.9 % among those with no ASD diagnosis; $p = 0.001$). There was no significant difference in obesity rates across ASD severities. There were no significant differences in physical activity rates among those with an ASD diagnosis compared to those with no diagnosis. This finding held when examining physical activity by ASD severity. Moreover, there was no significant difference in sedentary behavior when examining ASD diagnosis as a dichotomous outcome. However, when examining sedentary behavior by ASD severity, those with severe ASD reported significantly higher rates of such

Table 1 Sample description of children aged 6–17 from the 2011–2012 NSCH (N = 49,586,134)

	Total	ASD diagnosis		*p*	ASD severity			*p*
		No	Yes		Mild	Moderate	Severe	
N (%)								
		48,598,466 (98)	986,352 (2)		517,797 (52.5)	333,287 (33.8)	135,268 (13.7)	
Obese	4,974,917 (10)	4,813,098 (9.9)	161,492 (16.4)	0.001	78,616 (15.2)	60,091 (18)	22,785 (16.8)	0.839
Overweight	4,960,244 (10)	4,844,738 (10)	115,279 (11.7)	0.346	53,130 (10.3)	43,016 (12.9)	19,134 (14.1)	0.737
Physical activity	13,765,105 (28)	13,512,308 (28.1)	252,257 (25.8)	0.452	129,564 (25)	93,756 (28.6)	28,937 (21.7)	0.731
Sedentary behavior	23,503,669 (47.6)	23,026,866 (47.6)	475,487 (48.23)	0.843	263,325 (50.9)	124,240 (37.3)	87,923 (65.1)	0.011
Demographic variables								
Male	25,357,992 (51.2)	24,540,412 (50.6)	816,263 (82.8)	0.000	419,409 (81)	285,817 (85.8)	111,037 (82.1)	0.569
Age 12–17	25,110,210 (50.6)	24,643,878 (50.7)	465,764 (47.2)	0.256	253,799 (49)	147,157 (44.2)	64,808 (47.9)	0.795
Non-White	16,108,237 (33.6)	15,845,002 (33.7)	262,855 (27)	0.057	105,457 (20.7)	99,985 (30.2)	57,413 (42.5)	0.083
Hispanic	10,768,661 (22.2)	10,595,171 (22.3)	173,489 (17.8)	0.233	57,286 (11.2)	78,003 (23.6)	38,201 (28.5)	0.129
Census region								
Northeast	8,298,439 (16.7)	8,110,039 (16.7)	188,400 (19.1)	0.211	126,161 (24.4)	46,104 (13.8)	161,36 (11.9)	0.019
South	18,594,542 (37.5)	18,269,397 (37.6)	324,765 (32.9)	0.097	177,599 (34.3)	104,915 (31.5)	42,252 (31.2)	0.875
Midwest	10,775,877 (21.7)	10,552,124 (21.7)	223,753 (22.7)	0.647	115,450 (22.3)	77,843 (23.4)	30,460 (22.5)	0.976
West	11,917,276 (24)	11,666,906 (24)	249,434 (25.3)	0.709	98,588 (19)	104,425 (31.3)	46,421 (34.3)	0.187
Secondary conditions								
Intellectual disability	618,243 (1.2)	373,823 (0.8)	244,420 (24.8)	0.000	51,687 (10)	104,006 (31.2)	88,727 (65.6)	0.000
ADHD	4,923,143 (10)	4,516,013 (9.3)	406,843 (41.2)	0.000	225,295 (43.5)	142,118 (42.6)	39,429 (29.1)	0.280
Learning disability	4,542,862 (9.2)	3,822,492 (7.9)	719,378 (72.9)	0.000	339,019 (65.5)	256,746 (77)	123,613 (91.4)	0.001
Developmental delay	1,693,983 (3.4)	1,131,166 (2.3)	562,225 (57)	0.000	237,863 (45.9)	200,158 (60)	124,204 (91.8)	0.000
Mental health condition[a]	3,629,952 (7.3)	3,123,366 (6.4)	505,768 (51.3)	0.000	212,276 (41)	186,250 (55.9)	107,242 (79.3)	0.000
Physical condition[b]	1,399,825 (2.8)	1,288,468 (2.7)	111,357 (11.3)	0.000	37,359 (7.2)	38,109 (11.4)	35,888 (26.5)	0.001
Medical condition[c]	5,545,875 (11.2)	5,345,633 (11)	199,915 (20.3)	0.000	91,837 (17.7)	61,661 (18.5)	46,418 (34.3)	0.057
Other condition[d]	3,378,490 (6.8)	2,807,933 (5.8)	570,033 (57.8)	0.000	214,616 (41.4)	234,721 (70.4)	120,696 (89.2)	0.000
Medication use[e]	1,428,262 (3.1)	1,233,231 (2.7)	194,504 (28.1)	0.000	86,650 (25.4)	63,284 (25.7)	44,570 (42.9)	0.200

Weighted Ns and percentages are presented. May not sum to 100 %. Percents based on N for each category

[a] Depression, anxiety, behavior/conduct problems

[b] Cerebral palsy, bone/joint/muscle problems

[c] Asthma, diabetes, epilepsy/seizure disorder

[d] Brain injury/concussion, speech/language, vision, hearing problems, Tourette syndrome

[e] For difficulties with emotion, concentration, or behavior unrelated to ADD/ADHD

Table 2 Adjusted odds ratios for obesity, 2011–2012 NSCH, Children age 6–17

	ASD diagnosis		ASD severity	
	Model A (N = 47,840,412) Adj OR (95 % CI)	Model B (N = 44,463,485) Adj OR (95 % CI)	Model A (N = 972,488) Adj OR (95 % CI)	Model B (N = 685,189) Adj OR (95 % CI)
ASD diagnosis				
No	1.00	1.00	–	–
Yes	1.76 (1.27–2.43)***	1.07 (0.64–1.80)	–	–
Autism severity				
Mild	–	–	1.00	1.00
Moderate	–	–	1.30 (0.66–2.56)	1.23 (0.56–2.70)
Severe	–	–	1.12 (0.44–2.84)	0.89 (0.16–5.00)
Sex				
Female	1.00	1.00	1.00	1.00
Male	1.47 (1.29–1.68)***	1.51 (1.32–1.73)***	2.37 (0.91–6.16)	1.82 (0.55–6.04)
Age				
6–11	1.00	1.00	1.00	1.00
12–17	2.25 (1.96–2.57)***	2.21 (1.91–2.55)***	5.41 (2.79–10.47)***	7.81 (3.37–18.10)***
Race				
White	1.00	1.00	1.00	1.00
Non-White	1.47 (1.28–1.68)***	1.48 (1.28–1.70)***	1.28 (0.60–2.73)	1.27 (0.47–3.46)
Ethnicity				
Non-hispanic	1.00	1.00	1.00	1.00
Hispanic	1.42 (1.19–1.69)***	1.47 (1.23–1.75)***	1.33 (0.50–3.53)	2.21 (0.72–6.80)
Census region				
Northeast	1.00	1.00	1.00	1.00
South	1.26 (1.07–1.48)**	1.32 (1.11–1.56)***	0.85 (0.38–1.90)	0.40 (0.13–1.24)
Midwest	1.25 (1.06–1.47)**	1.26 (1.06–1.49)**	1.47 (0.68–3.22)	1.72 (0.69–4.26)
West	0.91 (0.73–1.13)	0.95 (0.76–1.18)	0.86 (0.38–1.90)	1.09 (0.37–3.15)
Secondary conditions				
Intellectual disability	–	0.97 (0.47–2.00)	–	0.61 (0.18–2.09)
ADHD	–	0.90 (0.61–1.34)	–	0.32 (0.12–0.86)*
Learning disability	–	1.51 (1.19–1.93)***	–	1.52 (0.58–4.00)
Developmental delay[a]	–	1.02 (0.63–1.65)	–	0.67 (0.23–1.96)
Mental Health condition[b]	–	1.14 (0.84–1.56)	–	0.99 (0.47–2.07)
Physical condition[c]	–	1.12 (0.74–1.68)	–	0.84 (0.28–2.53)
Medical condition[d]	–	1.15 (0.97–1.37)	–	2.68 (1.06–6.81)*
Other condition[e]	–	1.14 (0.87–1.49)	–	1.14 (0.51–2.57)
Medication use				
Yes[e]	–	1.57 (1.09–2.26)*	–	0.92 (0.40–2.14)

Weighted Ns are presented

[a] Excludes ASD

[b] Depression, anxiety, behavior/conduct problems

[c] Cerebral palsy, bone/joint/muscle problems

[d] Asthma, diabetes, epilepsy/seizure disorder

[e] Brain injury/concussion, speech/language problems, vision problems, hearing problems, Tourette syndrome

[f] For difficulties with emotion, concentration, or behavior unrelated to ADD/ADHD

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

behavior (65.1 vs. 50.9 % of children with mild severity and 37.3 % of children with moderate severity ASD; $p = 0.011$).

For each outcome variable of interest, we present two models in our multivariate analyses (see Tables 2, 3, 4). In each case, Model A examines the relationship between

Table 3 Adjusted odds ratios for overweight, 2011–2012 NSCH, Children age 6–17

	ASD diagnosis		ASD severity	
	Model A (N = 47,840,412) Adj OR (95 % CI)	Model B (N = 44,463,485) Adj OR (95 % CI)	Model A (N = 972,488) Adj OR (95 % CI)	Model B (N = 685,189) Adj OR (95 % CI)
ASD diagnosis				
No	1.00	1.00	–	–
Yes	1.20 (0.82–1.77)	1.42 (0.92–2.18)	–	–
Autism severity				
Mild	–	–	1.00	1.00
Moderate	–	–	1.38 (0.59–3.21)	0.79 (0.27–2.28)
Severe	–	–	1.51 (0.56–4.09)	1.67 (0.51–5.50)
Sex				
Female	1.00	1.00	1.00	1.00
Male	1.12 (0.99–1.26)	1.13 (1.00–1.28)	0.90 (0.41–1.98)	0.68 (0.27–1.76)
Age				
6–11	1.00	1.00	1.00	1.00
12–17	2.90 (2.54–3.30)***	2.95 (2.57–3.38)***	1.96 (0.97–3.98)	2.25 (0.97–5.24)
Race				
White	1.00	1.00	1.00	1.00
Non-White	1.12 (0.98–1.28)	1.09 (0.95–1.25)	0.82 (0.30–2.28)	0.43 (0.14–1.28)
Ethnicity				
Non-Hispanic	1.00	1.00	1.00	1.00
Hispanic	1.10 (0.91–1.31)	1.07 (0.89–1.30)	1.00 (0.27–3.71)	1.60 (0.43–5.94)
Census region				
Northeast	1.00	1.00	1.00	1.00
South	1.05 (0.89–1.23)	1.06 (0.89–1.25)	1.03 (0.47–2.25)	1.14 (0.43–3.05)
Midwest	1.02 (0.87–1.19)	1.04 (0.88–1.22)	0.50 (0.20–1.24)	0.71 (0.24–2.08)
West	0.94 (0.77–1.15)	0.94 (0.76–1.14)	1.27 (0.44–3.62)	0.83 (0.24–2.84)
Secondary conditions				
Intellectual disability	–	0.83 (0.45–1.55)	–	0.93 (0.30–2.88)
ADHD	–	1.29 (0.89–1.88)	–	2.68 (1.18–6.11)*
Learning disability	–	1.00 (0.72–1.39)	–	0.52 (0.24–1.16)
Developmental delay[a]	–	1.00 (0.65–1.43)	–	1.56 (0.66–3.70)
Mental health condition[b]	–	0.95 (0.72–1.27)	–	1.16 (0.52–2.61)
Physical condition[c]	–	1.07 (0.78–1.47)	–	1.47 (0.37–5.88)
Medical condition[d]	–	1.23 (1.03–1.47)*	–	0.53 (0.15–1.85)
Other condition[e]	–	0.83 (0.61–1.12)	–	0.74 (0.31–1.76)
Medication use				
Yes[e]	–	1.16 (0.84–1.59)	–	0.99 (0.45–2.21)

Weighted Ns are presented

[a] Excludes ASD

[b] Depression, anxiety, behavior/conduct problems

[c] Cerebral palsy, bone/joint/muscle problems

[d] Asthma, diabetes, epilepsy/seizure disorder

[e] Brain injury/concussion, speech/language problems, vision problems, hearing problems, Tourette syndrome

[f] For difficulties with emotion, concentration, or behavior unrelated to ADD/ADHD

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

autism diagnosis or severity and the outcome variable while controlling for gender, age, race, ethnicity, and geographic location. Model B additionally controls for indicator variables for each secondary condition and medication use. With respect to obesity (Table 2), our findings from Model A suggests that having an ASD

Table 4 Adjusted Odds Ratios for Physical Activity, 2011–2012 NSCH, Children age 6–17

	ASD diagnosis		ASD severity	
	Model A (N = 47,424,437) Adj OR (95 % CI)	Model B (N = 44,075,569) Adj OR (95 % CI)	Model A (N = 964,916) Adj OR (95 % CI)	Model B (N = 679,914) Adj OR (95 % CI)
ASD diagnosis				
No	1.00	1.00	–	–
Yes	0.75 (0.55–1.02)	0.71 (0.47–1.06)	–	–
Autism severity				
Mild	–	–	1.00	1.00
Moderate	–	–	1.04 (0.59–1.83)	1.18 (0.64–2.20)
Severe	–	–	0.71 (0.25–2.02)	0.66 (0.20–2.14)
Sex				
Female	1.00	1.00	1.00	1.00
Male	1.63 (1.50–1.77)***	1.61 (1.48–1.76)***	1.81 (0.88–3.71)	1.12 (0.50–2.52)
Age				
6–11	1.00	1.00	1.00	1.00
12–17	0.45 (0.41–0.48)***	0.45 (0.42–0.50)***	0.39 (0.22–0.69)***	0.64 (0.34–1.20)
Race				
White	1.00	1.00	1.00	1.00
Non-White	0.97 (0.89–1.07)	0.97 (0.88–1.07)	0.78 (0.40–1.53)	0.98 (0.49–1.96)
Ethnicity				
Non-Hispanic	1.00	1.00	1.00	1.00
Hispanic	0.66 (0.58–0.75)***	0.65 (0.56–0.74)***	1.37 (0.54–3.43)	1.16 (0.47–2.86)
Census region				
Northeast	1.00	1.00	1.00	1.00
South	1.27 (1.15–1.42)***	1.29 (1.16–1.44)***	1.53 (0.73–3.18)	1.07 (0.43–2.63)
Midwest	1.09 (0.98–1.21)	1.11 (0.99–1.24)	0.96 (0.46–2.04)	0.64 (0.25–1.61)
West	1.10 (0.96–1.27)	1.12 (0.97–1.29)	1.60 (0.67–3.83)	0.89 (0.35–2.28)
Secondary conditions				
Intellectual disability	–	0.61 (0.39–0.95)*	–	0.61 (0.25–1.48)
ADHD	–	1.47 (1.11–1.94)**	–	3.18 (1.50–6.77)**
Learning disability	–	1.10 (0.90–1.34)	–	1.19 (0.58–2.43)
Developmental delay[a]	–	1.04 (0.76–1.42)	–	0.79 (0.42–1.50)
Mental health condition[b]	–	0.92 (0.75–1.14)	–	1.97 (1.08–3.59)*
Physical condition[c]	–	0.99 (0.74–1.33)	–	1.03 (0.41–2.59)
Medical condition[d]	–	0.92 (0.81–1.04)	–	0.55 (0.25–1.19)
Other condition[e]	–	1.14 (0.94–1.38)	–	3.90 (2.06–7.39)***
Medication use				
Yes[e]	–	0.76 (0.57–1.03)	–	0.98 (0.50–1.95)

Weighted Ns are presented

[a] Excludes ASD

[b] Depression, anxiety, behavior/conduct problems

[c] Cerebral palsy, bone/joint/muscle problems

[d] Asthma, diabetes, epilepsy/seizure disorder

[e] Brain injury/concussion, speech/language problems, vision problems, hearing problems, Tourette syndrome

[f] For difficulties with emotion, concentration, or behavior unrelated to ADD/ADHD

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

diagnosis is associated with a higher likelihood of being obese (OR 1.76; 95 % CI 1.27–2.43). However, when controlling for secondary conditions and medication use in Model B, an ASD diagnosis is no longer associated with obesity. Instead, having a learning disability (OR 1.51; 95 % CI 1.19–1.93) or medication use (OR 1.57; 95 % CI

1.09–2.26) is associated with an increased likelihood of being obese. When examining obesity by ASD severity, no significant associations were found in either Model A or B. Likewise, there were no significant associations between either ASD diagnosis or ASD severity and being overweight in any models (Table 3).

With respect to physical activity (Table 4), no significant associations were found between either ASD diagnosis or ASD severity and physical activity. However, when examining ASD diagnosis and physical activity in Model B, children with an intellectual disability were found to have significantly lower odds of engaging in recommended levels of physical activity (OR 0.61; 95 % CI 0.39–0.95). Those with ADHD were found to have significantly higher odds of meeting physical activity guidelines (OR 1.47; 95 % CI 1.11–1.94). When examining ASD severity and physical activity in Model B, the presence of an ADHD diagnosis remained significant (OR 3.18; 95 % CI 1.50–6.77). Likewise, those with a mental health condition (OR 1.97; 95 % CI 1.08–3.59) or some other condition (OR 3.90; 95 % CI 2.06–7.39) also had significantly increased odds of meeting physical activity recommendations.

Lastly, no significant associations were found between ASD diagnosis and sedentary behavior (Table 5). The presence of a learning disability was associated with significantly higher odds of reporting sedentary behavior (OR 1.36; 95 % CI 1.13–1.62) in Model B for ASD diagnosis. When examining ASD by severity, children with moderate ASD were less likely to be sedentary in Model A (OR 0.58; 95 % CI 0.36–0.93). However, this finding was no longer observed after controlling for secondary conditions and medication use. In Model B for ASD severity and sedentary behavior, those children with developmental delay were found to have significantly increased odds of reporting sedentary behavior (OR 2.01; 95 % CI 1.08–3.71). Those diagnosed with some other condition had significantly lower odds of reporting sedentary behavior (OR 0.36; 95 % CI 0.20–0.66).

Discussion

Our analyses indicate that ASD is not independently related to obesity once other secondary conditions and medication use are taken into account. From our results, it seems that the presence of a learning disability is more likely associated with being obese than the presence of ASD alone, as is medication use for emotions, concentration or behavior. This is consistent with literature indicating that medications taken by individuals with these diagnoses contribute to weight gain and that these individuals may exhibit irregular or suboptimal dietary patterns [4, 10, 11, 22, 25]. However, the impact of medication use is unclear, as it is no longer significant when ASD is examined by severity. Furthermore, medication use was not related to overweight status in any of our analyses of ASD (both presence of diagnosis and severity). Importantly, in our study, neither autism diagnosis nor ASD severity were associated with being overweight in any of our analyses.

No significant associations were found between ASD presence or severity and physical activity. This is in contrast to previous findings that children with ASD engage in less physical activity as they age [13, 16, 20] and are less physically active than their peers without disabilities [2]. However, a more recent study found that children and youth with ASD within the study sample did meet the 2008 Physical Activity Guidelines, set by the US Department of Health and Human Services, of 60 min/day of moderate-to-vigorous physical activity, despite being less physically active than their peers without disabilities [26]. Our measure of physical activity was also based upon this recommendation. Our lack of significant findings may be reflective of these seemingly contradictory findings, whereby children with ASD report less physical activity overall compared to their peers without disabilities, yet still meet recommended activity guidelines.

We found no independent association between ASD diagnosis and sedentary behavior. We found that sedentary behavior differed by ASD severity whereby individuals with moderate ASD were less likely to be sedentary compared to those with mild ASD. However, this finding was no longer observed after controlling for secondary diagnoses or conditions and medication use. Our findings are in contrast to previous studies that found increased screen time usage (as a measure of sedentary behavior) by individuals with an ASD [14, 15, 17, 23]. However, previous studies did not examine levels of ASD severity as separate categories. Furthermore, previous studies used smaller sample sizes and less generalizable geographic locations and age groups. Therefore, it is with caution that comparisons be made across studies on sedentary behaviors. Further research is warranted to better understand how ASD impacts the frequency of sedentary behavior.

Despite the new contribution of the current study, several limitations are important to note. First, our study relies on parental self-report (as part of a governmental survey) to capture information about ASD status and severity, the presence of secondary conditions, screen time, physical activity, and weight and height. We recognize that self-report may be suboptimal in some situations, including the report of the presence or absence of a given condition and severity. For example, while it is unlikely that a parent would not know whether their child was diagnosed by a physician or other provider with ASD, we recognize that the severity of ASD may be less clear to some parents. In fact, the lack of a common definition for some conditions

Table 5 Adjusted Odds Ratios for Sedentary Behavior, 2011–2012 NSCH, Children age 6–17

	ASD diagnosis		ASD severity	
	Model A (N = 47,614,191) Adj OR (95 % CI)	Model B (N = 44,258,240) Adj OR (95 % CI)	Model A (N = 972,004) Adj OR (95 % CI)	Model B (N = 684,706) Adj OR (95 % CI)
ASD diagnosis				
No	1.00	1.00	–	–
Yes	1.01 (0.78–1.30)	0.72 (0.51–1.01)	–	–
Autism severity				
Mild	–	–	1.00	1.00
Moderate	–	–	0.58 (0.36–0.93)*	0.75 (0.42–1.32)
Severe	–	–	1.87 (0.79–4.41)	1.94 (0.78–4.84)
Sex				
Female	1.00	1.00	1.00	1.00
Male	1.35 (1.26–1.46)***	1.33 (1.23–1.43)***	1.26 (0.75–2.12)	1.35 (0.72–2.55)
Age				
6–11	1.00	1.00	1.00	1.00
12–17	1.51 (1.40–1.62)***	1.46 (1.35–1.58)***	1.38 (0.88–2.15)	1.35 (0.82–2.23)
Race				
White	1.00	1.00	1.00	1.00
Non-White	1.44 (1.32–1.56)***	1.44 (1.32–1.57)***	1.03 (0.61–1.76)	1.81 (1.04–3.15)*
Ethnicity				
Non-Hispanic	1.00	1.00	1.00	1.00
Hispanic	1.32 (1.18–1.47)***	1.32 (1.18–1.48)***	0.53 (0.25–1.13)	0.51 (0.24–1.11)
Census region				
Northeast	1.00	1.00	1.00	1.00
South	1.09 (0.99–1.20)	1.10 (1.00–1.21)	0.97 (0.55–1.73)	0.59 (0.30–1.18)
Midwest	1.08 (0.99–1.19)	1.06 (0.96–1.17)	1.13 (0.64–2.00)	1.07 (0.53–2.18)
West	0.80 (0.71–0.90)***	0.82 (0.73–0.93)**	1.25 (0.63–2.50)	0.99 (0.47–2.12)
Secondary conditions				
Intellectual disability	–	0.94 (0.61–1.52)	–	1.10 (0.55–2.20)
ADHD	–	1.20 (0.94–1.52)	–	0.89 (0.44–1.81)
Learning disability	–	1.36 (1.13–1.62)***	–	1.35 (0.77–2.37)
Developmental delay[a]	–	1.12 (0.84–1.50)	–	2.01 (1.08–3.71)*
Mental health condition[b]	–	1.15 (0.95–1.40)	–	1.49 (0.88–2.54)
Physical condition[c]	–	1.05 (0.83–1.33)	–	0.60 (0.22–1.60)
Medical condition[d]	–	1.10 (0.97–1.24)	–	0.63 (0.33–1.21)
Other condition[e]	–	0.85 (0.71–1.02)	–	0.36 (0.20–0.66)***
Medication use				
Yes[e]	–	1.10 (0.88–1.38)	–	0.97 (0.55–1.73)

Weighted Ns are presented

[a] Excludes ASD

[b] Depression, anxiety, behavior/conduct problems

[c] Cerebral palsy, bone/joint/muscle problems

[d] Asthma, diabetes, epilepsy/seizure disorder

[e] Brain injury/concussion, speech/language problems, vision problems, hearing problems, Tourette syndrome

[f] For difficulties with emotion, concentration, or behavior unrelated to ADD/ADHD

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

included in our analysis is also a limitation. For example, the scientific literature varies with definitions of learning disability and some authors may use the term synonymously with intellectual disability. In the education literature, the term is usually consistent with definitions in federal law used to qualify students for special education

services [9]. The limitations related to self-report, particularly of condition of severity, may bias the results of this study. Thus, future research should try to validate some of the self-reported conditions used in the current study, especially those in which the severity of a condition may be impacting the outcomes of interest.

The questions included in the NSCH limit the ability to explore variables in a detailed way. For example, dependent variables were necessarily based upon single survey questions, hampering a nuanced understanding of complex phenomena, including our outcomes of interest. Dichotomizing dependent variables may also result in a loss of detailed information, though sensitivity analyses suggest that dependent variables were not sensitive to changes in how these variables were coded (data not shown). The lack of specific medication use data in the NSCH limits the interpretation of the medication use variable. We were unable to determine if medication was prescribed as a result of the ASD diagnosis or some other condition that affects emotions, concentration, or behavior. We were also unable to determine the exact type of medication prescribed and possible related side effects, including effects on weight. Furthermore, the NSCH does not include a question regarding diet, so we are unable to control for the confounding effect that diet may have upon the relationship between ASD and obesity and overweight status.

Another limitation of our study is the availability of national data that only allows for cross-sectional analyses. As such, the results we present can only be interpreted as associations. Finally, while we believe that we have made an important contribution by examining ASD by severity in an attempt to capture the spectrum aspect of the disorder, subdividing the data in this way resulted in small sample sizes for analysis, as so few participants reported severe ASD. Because of these small sample sizes, our estimates of the associations between ASD severity and our four outcomes are not as precise (i.e. have larger confidence intervals than for the dichotomous ASD versus no ASD) and should therefore be interpreted with caution. However, as rates of secondary conditions were found to differ significantly across ASD severities, we believe future research should further examine ASD by severity in addition to the presence of the disorder.

Conclusion

In conclusion, ASD diagnosis and severity were not independently associated with obesity or overweight status or the likelihood of engaging in physical activity after controlling for secondary conditions and medication use. Moderate ASD was associated with lower sedentary behaviors, but this finding was no longer observed after controlling for secondary conditions and medication use. These findings highlight the importance of considering these secondary conditions in any examination of the relationship between ASD and obesity, overweight, physical activity, and sedentary behavior. Decision makers, clinicians, and researchers developing interventions for children with ASDs should consider how secondary conditions may impact weight and related activities.

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