


## RESEARCH ARTICLE

# Influence of Neighborhood Environment on Physical Activity Participation among Children with Autism Spectrum Disorder

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Despite the positive influence of environmental factors on physical activity (PA) levels of children, further investigation is necessary when considering the unique characteristics of children with autism spectrum disorder (ASD). The purpose of this study was to examine the relationship between neighborhood environment factors and PA among children with ASD by examining the extent to which (a) the built environment, (b) neighborhood safety, and (c) neighborhood support contributes to PA. A secondary data analysis using the 2016 and 2017 combined dataset of the National Survey of Children's Health was used. The total sample included 14,944 children between the ages of 6–17 years; of this, a sample of 494 children had a parent-reported diagnosis of ASD. Multivariate logistic regressions were conducted to explore the unique influences of the above three neighborhood environment factors on PA engagement. Among children with and without ASD, an association was found between feeling safe and engaging in PA, that is, the odds of engaging in PA are greater among children who were safe in their neighborhoods than children who were not in safe neighborhoods. Surprisingly, other neighborhood factors do not have a significant relationship with PA participation among children with ASD at this time. Future studies should consider how to incorporate the support of others and feeling of safety into the neighborhood along with how to improve accessibility of the built environment in order to increase PA for children with ASD. *Autism Res* 2020, 00: 1–11. © 2020 International Society for Autism Research and Wiley Periodicals LLC

**Lay Summary:** The results of this study showed that neighborhood factors influence physical activity (PA) among children with ASD differently compared to their peers without ASD. Children with ASD who live in safe neighborhoods are more likely to engage in PA, while other neighborhood factors, such as playgrounds and support, are not associated with an increased likelihood of engaging in PA at this time. Efforts should be made to improve neighborhood accessibility and design in order to increase PA among children with ASD.

**Keywords:** autism; neighborhood; physical activity; built environment; safety; support

Physical activity (PA) plays important roles in the health and wellbeing of children, including an increase in positive health outcomes such as greater bone strength, maintenance of a healthier weight status, improved cardiovascular risk factor status, and fewer symptoms of depression [2018 Physical Activity Guidelines Advisory Committee, 2018]. To promote PA-related health benefits, national PA guidelines have been implemented to ensure Americans are engaging in sufficient amounts each day. The current edition of the Physical Activity Guidelines for Americans recommends that children and adolescents, with and without disabilities, between the ages of 6 and 17 years engage in at least 60 min of moderate-to-vigorous physical activity (MVPA) daily [U.S. Department of Health and Human Services, 2018]. While guidelines are in place to help Americans engage in more PA, individuals may not be achieving these recommendations. However, researchers

have documented that engaging in some PA throughout the day, regardless of meeting guidelines, is still better for health outcomes than none [2018 Physical Activity Guidelines Advisory Committee, 2018; Sattelmair et al., 2011].

Recent attention has been brought to the PA behaviors of children with autism spectrum disorder (ASD), which is important given the most recent prevalence estimate that 1 in 54 children have ASD [Maenner et al., 2020]. It is also important to note that researchers have documented that the majority of children with ASD do not meet the current national PA guidelines for health benefits [Case, Ross, & Yun, 2020; Stanish et al., 2019]. Case and her colleagues reported only 14.2% of children with ASD between 6 and 17 years old participated in 60 min of PA daily. Furthermore, McCoy, Jakicic, and Gibbs [2016] reported that children with ASD are 60% less likely to engage in regular PA than children without ASD and 74% less likely to have

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participated in a sport compared to children without ASD. Agiovlasitis, Yun, Jin, McCubbin, and Motl [2018] argued that PA promotion is a complex endeavor and that interacting personal and environmental factors must be considered. However, many previous studies have focused solely on person-related factors including motor difficulties [Jones et al., 2017], having few friends [Must, Phillips, Curtin, & Bandini, 2015], and impaired social skills [Reichow, Steiner, & Volkmar, 2013].

Environmental factors have been identified as a critical influence on children's health behaviors, including PA [Aarts, Mathijssen, van Oers, & Schuit, 2013; Davison & Lawson, 2006; Healy, Garcia, & Haegele, 2018; Jin & Yun, 2013; Masoumi, 2017; Yan, Voorhees, Clifton, & Burnier, 2010]. Bronfenbrenner's Social Ecological Model (SEM) considers how the various levels of an individual's environment interact with one another, ultimately influencing behavior [Gauvain & Cole, 2005]. These levels include individual (intrapersonal), microsystem (interpersonal), mesosystem (organizational), exosystems (community), and the macrosystem (policy) [Gauvain & Cole, 2005]. Within this model, each level is influential on the other levels, with an individual's behavior supported or undermined by every layer.

In alignment with the SEM, there is evidence suggesting that an individual's surrounding environment, including the neighborhood, impacts PA behaviors [Davison & Lawson, 2006; Gordon-Larsen, Nelson, Page, & Popkin, 2006; Hinckson et al., 2017]. In fact, many factors within the neighborhood built environment, which includes parks, roadways, sidewalks, and playgrounds within the neighborhood, influence both subjective and objective PA levels of children [Masoumi, 2017]. For example, in a study examining PA levels among 400 children aged 2 to 9 years, living in a residential neighborhood with a park or playground, increased the child's likelihood of engaging in MVPA [Buck et al., 2015]. Additional neighborhood variables, including neighborhood social support and neighborhood safety, may also play an important role in child PA behaviors [Carver, Timperio, & Crawford, 2008; Esteban-Cornejo et al., 2016; Molnar, Gortmaker, Bull, & Buka, 2004; Rossen et al., 2011; Salvy, Feda, Epstein, & Roemmich, 2017; Weir, Etelson, & Brand, 2006]. In a review of multiple studies examining the influence of neighborhood safety on PA, parental perceptions of lack of neighborhood safety are associated with low levels of PA among children without disabilities [Carver et al., 2008]. Additionally, neighborhood social support and having supportive family and friends have been shown to increase PA [McNeill, Kreuter, & Subramanian, 2006]. Collectively, these findings highlight the potential for various neighborhood factors to impact child PA behaviors and draw attention to the importance of understanding how to promote PA within the neighborhood environment.

Due to unique characteristics associated with the ASD diagnosis, children with ASD may interact with their neighborhood and engage in PA differently than children without ASD. For example, many children with ASD demonstrate challenges in social communication and often exhibit behaviors which may impact social interaction with others [Lampi, Fitzpatrick, Romero, Amaral, & Schmidt, 2018]. Difficulty in social communication combined with a higher degree of social impairment may impede the likelihood of engaging in PA for children with ASD [Jones et al., 2017]. In fact, Obrusnikova and Miccinello [2012] examined how children with ASD interact with the various components of the Social Ecological Model in respect to PA. Intrapersonal barriers, such as engaging in sedentary behaviors and lack of motivation, were reported as one of the most common factors to negatively impact engagement in PA. Extending this to the interpersonal and community levels, children with ASD may require greater social supports compared to their peers without ASD [Healy et al., 2018]. Additionally, they may face external barriers within their environment, such as excess noise or lights and crowdedness, which can have a negative effect on their participation [Krieger et al., 2018]. Having social support or being supported by others at the interpersonal level instead may increase engagement in PA [Pan, 2009]. In addition to social support, children with ASD often exhibit motor impairments and poor motor coordination [Fournier, Hass, Naik, Lodha, & Cauraugh, 2010], which may influence engagement in lifelong PA [Stodden et al., 2008]. It has also been noted that playgrounds may be overstimulating to children with ASD and they may need to be eased into this type of environment more gradually [McAllister, 2010]. Resultantly, these findings demonstrate that children with ASD may interact with their neighborhood environment in different and unique manners than reported among children without ASD.

Given the potential influence of the neighborhood environment on PA behaviors of children and the unique characteristics of children with ASD, there is a need to investigate the relationship between neighborhood factors and engagement in PA specifically among children with ASD. A few previous studies have investigated the influence of neighborhood factors on PA among this population [Healy et al., 2018; Obrusnikova & Miccinello, 2012], but it is necessary to examine multiple neighborhood variables given the nuanced experiences of children with ASD. Furthermore, it is important to obtain updated estimates using nationally representative data considering previous national survey questions have been updated to better align with current PA recommendations. Therefore, the purpose of this study was to examine the relationship between various neighborhood factors and PA engagement among children with and without ASD. The current study had three specific aims.

The first aim was to examine the extent to which the built environment contributes to PA in children with and without ASD. The second aim was to examine the extent that neighborhood safety contributes to PA engagement. The third aim was to examine the extent to which neighborhood support contributes to PA engagement.

## Methods

### Data Source

This study was a secondary data analysis using the 2016 and 2017 combined National Survey of Children's Health (NSCH) dataset. The primary goal of the NSCH is to provide rich data on multiple health and well-being variables of children living in the United States, including all 50 states and Washington D.C., between the ages of 0–17 years. The survey consists of responses from parents and/or legal guardian of non-institutionalized children. For both the 2016 and 2017 NSCH, randomly selected U.S. households received invitations to participate in web-based or mail surveys.

Parents initially completed a household screener to assess demographic characteristics and special health care needs of children present in the home. Upon the presence of a child in the household, respondents subsequently completed one of three age-specific surveys for selected children: (a) 0–5 years, (b) 6–11 years, or (c) 12–17 years. Among households with multiple children, children with special health care needs and children ages 0–5 years were oversampled in order to ensure representation of these groups. The total sample size for the 2016–2017 combined data consisted of 534,876 participants. Of that, 99,112

completed the survey. Additional information on the survey can be found elsewhere through the data resource center for child and adolescent health [U.S. Census Bureau, 2018].

### Sample/Participants

The analytic sample used in this study includes 15,438 U.S. school-age children between the ages of 6 and 17 years. Among this sample, a total of 494 children had a parent-reported diagnosis of ASD and 14,944 children without ASD. Children used in this sample were identified as having an ASD diagnosis based on affirmative responses to both of the following survey items: “Has a doctor or other health care provider EVER told you that this child has Autism or Autism Spectrum Disorder (ASD)?” and “If yes, does this child CURRENTLY have the condition?” Those without ASD were not restricted to a given diagnosis or special health care need. Descriptive sample characteristics, including age, sex, BMI classification, and race, are displayed in Table 1. On average, participants were primarily Caucasian, aged  $12.24 \pm 3.46$  with 46.7% in the normal range for BMI for those without ASD and aged  $12.44 \pm 3.13$  with 51.6% in the normal range for BMI for those with ASD.

### Variables

In order to examine the effects of neighborhood variables on PA participation, three different categories (groups) of neighborhood-related variables, including (a) built environment, (b) neighborhood safety, and (c) neighborhood support, were created using ten separate NSCH items.

**Table 1. Characteristics of School-Aged Children with and without ASD (6–17 Years) Participating in 2016–2017 NSCH Questionnaire**

Variable	Children without ASD		Children with ASD	
	<i>n</i>	Mean/proportion	<i>n</i>	Mean/proportion
Sex, %				
Male	7,512	50.3%	386	78.1%
Female	7,432	49.7%	106	21.9%
Age, Years	14,944	$12.13 \pm 3.46$	494	$12.44 \pm 3.13$
BMI category, %				
Under weight (< 5th percentile)	674	4.5%	23	6.2%
Healthy weight (5th $\geq$ 85th percentile)	6,983	46.7%	191	51.6%
Overweight 85th $\geq$ 95th percentile	1,468	9.8%	65	17.6%
Obese $\geq$ 95th percentile	1,344	9.0%	91	24.6%
Race, %				
White alone	11,393	76.2%	390	78.9%
Black or African American alone	1,058	7.1%	29	5.9%
American Indian or Alaska Native alone	105	0.7%	3	0.6%
Asian alone	800	5.4%	18	3.6%
Native Hawaiian alone	50	0.3%	1	0.2%
Some other race alone	407	2.7%	16	3.2%
Two or more races	1,131	7.6%	37	7.5%

Note. *n* = 15,438.

Each neighborhood group included 2–4 levels based on the separate survey items defined within the specific group.

**Built environment.** The built environment is comprised of man-made structures or alterations such as parks, roadways, sidewalks, and playgrounds [Masoumi, 2017]. The neighborhood-built environment was defined using four separate survey items: “In your neighborhood, is/are there: (1) Sidewalks or walking paths? (2) A park or playground? (3) A recreation center, community center, or boys’ and girls’ club? (4) A library or bookmobile?” Possible responses to each of the four survey items included (a) *yes* or (b) *no*.

**Neighborhood safety.** Neighborhood safety-related variables were identified through factors such as pedestrian safety, stranger danger, and crime safety as reported in a previous study by Esteban-Cornejo et al. [2016]. Neighborhood safety was defined by four separate survey items. First, respondents answered the following three items: “In your neighborhood, is/are there: (1) Litter or garbage on the street or sidewalk? (2) Poorly kept or run-down housing? (3) Vandalism such as broken windows or graffiti?” Possible responses to each of these three survey items included (a) *yes* or (b) *no*. Then, with an additional item, respondents indicated the extent to which they agreed with the following statement about their neighborhood or community: “This child is safe in our neighborhood.” Responses to this survey item included: (1) *definitely agree*, (2) *somewhat agree*, (3) *somewhat disagree*, and (4) *definitely disagree*. Responses to this specific item were collapsed into a dichotomous variable indicating if respondents (a) agreed or (b) disagreed with that statement.

**Neighborhood support.** Neighborhood support was defined by two separate survey items. Respondents indicated the extent to which they agreed with the following two survey items: “People in this neighborhood help each other out” and “We watch out for each other’s children in this neighborhood.” Possible responses to this item included: (1) *definitely agree*, (2) *somewhat agree*, (3) *somewhat disagree*, and (4) *definitely disagree*. Responses to each of these items were dichotomously coded to indicate if respondents (a) agreed or (b) disagreed.

**Physical activity.** The dependent variable in this study was *engagement in PA*, which was defined by a single survey item: “During the past week, on how many days did this child exercise, play a sport, or participate in physical activity for at least 60 minutes?” Responses to this survey item included: (1) *0 days*, (2) *1–3 days*, (3) *4–6 days*, or (4) *every day*. The responses were collapsed into a dichotomous variable indicating that children were

(a) active (1–7 days) or (b) inactive (0 days). Participants were coded as active and inactive due to the purpose of this study examining the influence of neighborhood factors on engagement of any form of PA. Since the survey item did not address the specific intensity of exercise for those days, we categorized responses as active versus inactive. Dichotomization of PA is commonly used among studies examining the relationship between greenspaces/neighborhood environments and PA as many are interested in the impact the environment has on overall PA engagement [e.g. Ambrey, 2016a, 2016b; Coombes, Jones, & Hillsdon, 2010; Jones, Hillsdon, & Coombes, 2009; Perales, del Pozo-Cruz, del Pozo-Cruz, & del Pozo-Cruz, 2014].

**Covariates.** Child characteristics, including age and sex, were selected as covariates in the analysis based on their potential influence on engagement in PA of children with and without disabilities [Esteban-Cornejo et al., 2016]. In PA settings, sex differences have been indicated between males and females [Belcher et al., 2010]. Previous studies have also reported that levels of PA were influenced by age [Jung, Leung, Schram, & Yun, 2018].

#### Data Analysis

Descriptive statistics were computed to summarize the variables of interest and the outcome variables. Separate multivariate logistic regression analyses were conducted to evaluate the unique influences of built environment, neighborhood safety, and neighborhood support on PA engagement of children with and without ASD. Crude and adjusted odd ratios, standard error estimates, and corresponding 95% confidence intervals (CI) were reported. Both crude and adjusted models were run. Odd ratios reported as greater than one indicates higher odds of being active compared to the reference group, whereas odd ratios reported as less than one indicates lower odds. All analyses were conducted using SPSS 24 statistical software (IBM, 2016). Alpha level was set at 0.05.

#### Results

Table 2 provides percentage data on neighborhood variables for children with and without ASD. Overall, the majority of children with and without ASD live in neighborhoods with the presence of sidewalks or walking paths and parks or playgrounds, but slightly less than 50% of children with and without ASD have access to a nearby recreation center. Also, most children with and without ASD were reported by parents to be safe in the neighborhood and to live in a supportive neighborhood.



**Table 2. Summary of Descriptive Statistics**

	ASD (%)	Without ASD (%)
Built environment		
Sidewalks or walking paths	66	71.2
Park or playground	71.8	72.8
Recreation center	45.9	48.6
Library or bookmobile	62.6	67.5
Safety		
Litter or garbage	15.6	14.1
Poorly kept or rundown housing	11.3	5.9
Vandalism	5.2	10.2
Child is safe in neighborhood	93.3	97.1
Support		
People in the neighborhood help each other	76.9	81.8
Watch out for other's children	89	89.6

Note. Percentages are out of 100 and indicate the percentage of those who answered yes to each survey item.

### *Effects of Neighborhood Built Environments*

It is interesting to note that children with and without ASD have different relationships between PA participation and built environment. Among children with ASD, the results of the logistic regression revealed that there is no significant association between variables within the built environment and engaging in PA, before and after adjusting covariates. However, among children without ASD, the results revealed one factor within the built environment variable – the presence of parks or playgrounds – was significantly related to PA engagement. Children in neighborhoods with a park or playground have significantly higher odds of engaging in PA than children without a park or playground (OR = 1.27, 95% CI [1.08, 1.50],  $P = 0.003$ ). Similarly, after accounting for age and sex, the odds of engaging in PA among children with a park or playground were 1.19 times the odds of those without a park or playground (aOR = 1.19, 95% CI [1.01, 1.40],  $P = 0.03$ ). Table 3 provides detailed information of both the crude and adjusted logistic regression analyzes for children with and without ASD.

### *The Influence of Neighborhood Safety*

The results also indicate that the perception of safe neighborhood environments is important for PA participation among both children with and without ASD, although the relationships between the individual safety factors vary. Among children with ASD, feeling safe in the neighborhood was associated with PA, after adjusting for age and sex. The adjusted odds of engaging in PA among children with ASD who are safe in their neighborhoods were nearly three times the odds of those who were not safe in

their neighborhoods (aOR = 2.71, 95% CI [1.13, 6.45],  $P = 0.024$ ). Variables within neighborhood safety were also significantly associated with being physically active among children without ASD, before and after accounting for covariates. The unadjusted odds of engaging in PA among those who feel safe in the neighborhood were approximately 1.5 times the odds of those did not feel safe (OR = 1.57, 95% CI [1.15, 2.14],  $p = 0.004$ ). Similar results were found after adjusting for covariates (aOR = 1.72, 95% CI [1.25, 2.37],  $P = 0.001$ ). Additionally, among children without ASD who live in poorly kept or rundown housing neighborhoods, the adjusted odds of engaging in PA were 0.79 times the odds of those who do not (aOR = 0.79, 95% CI [0.64, 0.99],  $P = 0.04$ ), suggesting this group has lower odds of being physically active.

### *The Influence of Neighborhood Support*

The results also revealed that children with and without ASD have different relationships between PA participation and variables associated with neighborhood support. Among children with ASD, the odd ratios of being active did not significantly differ based on people in the neighborhood helping each other out or based on watching out for others as shown in Table 3. Among children without ASD, however, the unadjusted odds of engaging in PA among those who live in neighborhoods in which people help each other out was approximately 1.5 times the odds of those not did not (OR = 1.47, 95% CI [1.21, 1.80],  $P < 0.001$ ). Results were similar after adjusting for age and sex (aOR = 1.50, 95% CI [1.23, 1.84],  $P < 0.001$ ). Similar results were also found for children without ASD who lived in neighborhoods in which parents reported to watch out for each other's children (OR = 1.57, 95% CI [1.28, 1.91],  $P < 0.001$ ; aOR = 1.52, 95% CI [1.24, 1.86],  $P < 0.001$ ).

## **Discussion**

The purpose of this study was to examine the relationship between neighborhood factors and PA engagement among children aged 6–17 with and without ASD, using a secondary analysis of the 2016–2017 combined NSCH data. The results indicate that feeling safe in the neighborhood was a significant predictor of PA engagement among children with ASD. Among children without ASD, the presence of parks or playgrounds, feeling safe in the neighborhood, and living in a neighborhood where people watch out for other children and help each other out were all significant predictors of PA engagement.

As addressed above, children living in a neighborhood with a park or playground were significantly more likely to engage in PA compared to those who did not, which is consistent with previous studies suggesting the positive

**Table 3. Results of Logistic Regression**

Variable	ASD						Without ASD					
	Non-adjusted model			Adjust model			Non-adjusted model			Adjust model		
	OR	SE	CI	OR	SE	CI	OR	SE	CI	OR	SE	CI
Built environment												
Sidewalks	0.86	0.28	[0.49, 1.48]	0.82	0.29	[0.46, 1.46]	1.04	0.07	[0.90, 1.10]	1.03	0.07	[0.87, 1.19]
Park	1.07	0.31	[0.58, 1.98]	1.05	0.32	[0.55, 2.00]	1.27*	0.08	[1.08, 1.50]	1.19*	0.08	[1.01, 1.40]
Recreation center	1.01	0.28	[0.58, 1.75]	1.05	0.28	[0.59, 1.84]	0.95	0.07	[0.95, 1.26]	1.12	0.07	[0.97, 1.30]
Library	1.39	0.28	[0.79, 2.44]	1.40	0.29	[0.79, 2.49]	0.87	0.07	[0.87, 1.19]	1.05	0.07	[0.90, 1.22]
Safety												
Litter	1.40	0.36	[0.68, 2.89]	1.27	0.38	[0.60, 2.68]	0.89	0.09	[0.75, 1.06]	0.85	0.09	[0.71, 1.02]
Housing	1.06	0.42	[0.46, 2.44]	1.10	0.44	[0.46, 2.62]	0.92	0.10	[0.67, 1.03]	0.79*	0.11	[0.64, 0.99]
Vandalism	0.48	0.51	[1.76, 1.33]	0.56	0.53	[0.19, 1.59]	1.02	0.14	[0.76, 1.3]	1.01	0.15	[0.75, 1.36]
Feel safe in the neighborhood	2.17	0.42	[0.94, 5.00]	2.71*	0.44	[1.13, 6.45]	1.57**	0.15	[1.15, 2.14]	1.72**	0.16	[1.25, 2.37]
Support												
Help each other	1.34	0.36	[0.69, 2.60]	1.38	0.34	[0.70, 2.73]	1.47***	0.10	[1.21, 1.80]	1.50***	0.10	[1.23, 1.84]
Watch out for other children	1.47	0.36	[0.76, 2.83]	1.58	0.34	[0.80, 3.11]	1.57***	0.10	[1.28, 1.91]	1.52***	0.10	[1.24, 1.86]

Note. The covariates for the adjusted model were age and sex. The reference point for each OR was the group that did not have the variable present (e.g., neighborhood without sidewalks). Neighborhood components are simplified in the table for the purpose of limiting text but are aligned with the original survey questions. For example, sidewalks align with *sidewalks and walking paths* from the NSCH.

\* $P < 0.05$ ; \*\* $P < 0.01$ ; \*\*\* $P < 0.001$ .

CI: confidence interval; OR: odds ratio, SE: standard error.

impact of the built environment for PA [Huston, Evenson, Bors, & Gizlice, 2003; Masoumi, 2017]. However, it was surprising to find that none of the factors associated with the built environment (i.e. presence of sidewalks or walking paths, park or playground, recreation center, or library) significantly related to engagement in PA among children with ASD. Considering the limited research on the influence of the built environment on PA among children with ASD, there is little evidence as to why such factors did not significantly contribute to engagement PA. It is possible, however, that children with ASD may interact with their neighborhood's-built environment differently than children without ASD. Ingram, Mayes, Troxell, and Calhoun [2007] found that 0% of children with ASD follow the rules of the game or sustain a conversation with peers (compared to 59% of peers without ASD), 10% engage in social play with peers (compared to 100% of peers without ASD), and 50% use playground equipment functionally (compared to 68% of peers without ASD). Along with these findings, the present results support that children with ASD may interact with the built environment differently than their peers and provide initial insight that the current built environment may not support PA engagement in the same way.

Children with ASD may also encounter unique barriers to accessing PA resources within the neighborhood-built environment. For parents of children with ASD, the built environment itself may present accessibility issues and, therefore, they do not allow their children to utilize those resources. Additionally, many children with ASD experience hypo- or hypersensitivities to sensory stimuli [American Psychiatric Association, 2013], which may challenge their abilities to access environments that encourage PA [Must et al., 2015]. For example, parks and playgrounds may be over-stimulating or may conflict with the range of sensory preferences observed among children with ASD [Menear, Smith, & Lanier, 2006]. A study by Obrusnikova and Cavalier [2011] found one interpersonal barrier to engaging in PA was a lack thereof or unsafe equipment. Collectively, these barriers may suggest that, despite the presence of PA resources within the neighborhood, children with ASD may need supports beyond parental supervision to access PA opportunities. In addition, children with ASD may be less likely to utilize resources or facilities, such as recreation centers or playgrounds, within the neighborhood built environment due to lack of knowledgeable staff qualified to support children with unique needs, often resulting in a barrier to PA engagement [Healy et al., 2018; Must et al., 2015; Rimmer, Riley, Wang, Rauworth, & Jurkowski, 2004]. It is important for future studies to examine how components of the built environment can positively affect PA engagement with the environment specifically for children with ASD. Understanding the underlying factors associated with a

lack of use of the built environment will inform future research and intervention efforts to increase engagement in PA and the park or recreation facility. For example, when designing playgrounds, architects may employ universal design to allow all children the ability to play in a given environment. Universal design focuses on creating an environment that can be used by all, in the greatest extent possible, without a need for adaptation [Steinfeld, Maisel, & Levine, 2012]. Sensory friendly playgrounds should include an appropriate level of physical challenge, support structured and imaginative play, and create independent areas that increase inclusion and accessibility for all children with ASD [Yuill, Strieth, Roake, Aspden, & Todd, 2007]. Community members should also be involved in the development process to ensure the needs of all children are being met.

The findings of this current study align with previous studies suggesting that perceptions of neighborhood safety play an important role in PA engagement for children with ASD [Carver et al., 2008; Esteban-Cornejo et al., 2016; Janssen, 2014; Rossen et al., 2011; Weir et al., 2006]. It is therefore not surprising to find that children with and without ASD who live in neighborhoods perceived as safe were significantly more likely to engage in PA compared to those who did not live in safe neighborhoods. However, these findings confirm the importance that neighborhoods are perceived as safe in order to increase PA engagement among children with and without ASD. In particular, children with ASD have unique behaviors that may be perceived as unsafe by parents or may contribute to lower safety [Ryan, 2010]. For example, based on findings from a population-based study, approximately 28% of children with ASD expressed self-injurious behavior such as head-banging, hair pulling, or skin scratching [Soke & Rosenberg, 2016]. These behaviors may add a layer of complexity to parents' perceptions of their child's safety in the neighborhood that may hinder engagement in PA. In fact, Carver, Timperio, Hesketh, and Crawford [2010] also reported that constrained behaviors by parents due to perceived lack of safety of their children have also specifically limited MVPA. These findings are similar to that of children without ASD as well, where a similar association exists between neighborhood safety and PA. Parents of children without ASD who perceived the environment as unsafe restricted their child's engagement in PA outdoors [Esteban-Cornejo et al., 2016; Molnar et al., 2004; Weir et al., 2006]. Moving forward, it will therefore be essential to understand how neighborhood safety plays a role in PA engagement as well as consider the unique characteristics of children with ASD that may influence parent perceptions of safety. Increasing factors for safety may increase parent's and children's perception of a safe neighborhood and in turn increase PA engagement for those currently at lower odds.

It was surprising to find that neighborhood support and being watched out for by others were not significant predictors of PA for children with ASD, especially considering previous reports that support is important for PA among children with ASD [Obrusnikova & Cavalier, 2011]. Potential explanations may be that parents of children with ASD are more protective or that children with ASD may not be easily or actively supported by others within the neighborhood. Must et al. [2015], for example, found that 60% of parents of children with ASD reported that their child requires too much supervision to engage in PA, which may suggest that, even within supportive neighborhoods, parents do not feel comfortable enough to allow PA. Additionally, neighborhood cohesion, social support, and safety are key determinants in increasing PA within the neighborhood [Quinn et al., 2019]. This occurs through having trust in neighbors, a sense of safety, and shared goals toward PA [Quinn et al., 2019], all of which may impact watching out for other children. Nevertheless, it is evident from previous literature that support, including that from friends, parents and siblings, is an important facilitator of PA for children with ASD [Obrusnikova & Cavalier, 2011]. However, the present study's inconclusive finding regarding neighborhood support and PA among children with ASD may indicate that this population needs specific supports made to increase PA within the neighborhood. Future efforts should therefore be made to explore how children with ASD can be uniquely supported within the neighborhood in order to promote PA.

While it is common among epidemiological studies to use binary logistic regression [e.g. Ambrey, 2016a, 2016b; Coombes et al., 2010; Jones et al., 2009; Perales et al., 2014], further information may be garnered from ordinal regression. Given the surprising results that all neighborhood variables except feeling safe did not significantly influence the odds of being physically active among children with ASD, a post-hoc ordinal logistic regression was conducted to examine these relationships more closely. Three levels of PA were used, including (a) 0 days active, (b) 1–6 days active, and (c) 7 days active, as opposed to the two levels used within the main analysis. According to the post-hoc analysis, feeling safe in the neighborhood remained the only variable associated with PA among children with ASD, after adjusting for age and sex (aOR = 2.24, 95% CI [1.01, 4.94],  $P = 0.047$ ). The odds of engaging in 7 days of PA versus the odds of the combined lower PA categories are 2.24 times higher for children with ASD who feel safe than those who do not feel safe. This indicates no differences were found in the direction or magnitude of association between feeling safe and PA using the expanded subgroups for PA. The similar findings of the main and post-hoc analyses collectively suggest that feeling safe plays an important role in PA participation among children with ASD and requires further attention.

It is important to address certain limitations of this research. One potential limitation of this study was the use of parent-report of their child's ASD with no formal physician confirmation. However, parent-report ASD diagnosis is more feasible for a large, nationally representative sample and still provides an initial understanding of the relationship between neighborhood and PA for children with ASD. In addition, in 2018, NSCH noted that while parent-report is not clinically validated, studies have shown a concordance rate of 93%–98% between parent-report and clinical diagnosis [Kogan et al., 2018]. Future research that includes physician-confirmed diagnosis may provide more opportunities to understand the relationship. A second potential limitation of this study was the use of parent-report as a proxy measure of PA. Although direct PA measurement may be more ideal, this is the nature of secondary data analysis. Despite the limitations of secondary data analysis, however, it is important to note that previous studies have suggested that proxy measures of PA demonstrate appropriate levels of reliability and validity evidence among individuals with disabilities [Johnson, Yun, & McCubbin, 2014; Williams, Rosenbaum, Gorter, McCauley, & Gulko, 2018]. We therefore believe that this research provides meaningful information toward investigating the unique relationship between PA and neighborhood variables for children with ASD. In addition, the publicly available NSCH dataset does not include potential participants identifiable information on neighborhood location (e.g., zip code) or type (e.g., rural, urban, city). This lack of information may limit further analysis on more in-depth research questions regarding how location influences the neighborhood environment or the neighborhood services that attract families of children with ASD to certain areas. Further research that accounts for the influence of location on the relationship between PA and neighborhood variables for children with and without ASD is warranted. Lastly, we chose to code the PA variable in a way that allowed us to examine whether or not neighborhood factors contributed to PA. As such, the findings of this study do not provide information necessary to investigate compliance with PA guidelines based on neighborhood variables. However, due to evidence that suggests any degree of PA is more beneficial than no activity [Sattelmair et al., 2011], we believe these findings are valuable and provide a starting point to investigate how neighborhood factors may influence PA engagement within this population. Recent data and information on PA guideline compliance among children with and without ASD can be found in other resources [2018 Physical Activity Guidelines Advisory Committee, 2018; Case et al., 2020]. In addition, this coding of PA did not allow this study to examine the magnitude of the relationship between environmental variables and multiple levels of PA among children with disabilities. Although examining

the magnitude of this relationship is beyond the scope of this study, it may provide further understanding of the influence of environmental factors on PA among children with ASD. Future studies should examine the magnitude of the relationship between various levels/intensities of PA and environmental factors. As the NSCH data do not provide information regarding PA intensity, researchers may need to measure PA using objective measures to explore those relationships.

In summary, this study used a large, nationally representative sample of children with and without ASD to provide insight into the relationship between neighborhood factors and PA among children with ASD. The results suggest that feeling safe in the neighborhood is vital for PA engagement among children with and without ASD. It is interesting to find that the relationship between PA engagement and the built environment is currently different among children with and without ASD. The present study's findings contribute to the literature by providing insight into the impact of multiple dimensions of neighborhoods on PA behaviors of children with and without ASD. Considering the potential importance of the built environment for PA participation, future studies should examine how neighborhood-built environments can be designed in order to better support and be inclusive of the unique characteristics of children with ASD.

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