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Environmental and social determinants of leisure-time physical activity in children with autism spectrum disorder

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ABSTRACT

Background: It is increasingly recognized that children's physical activity behaviors are shaped by neighborhood environment factors and their parent's support. However, these factors have been scarcely studied among children with autism spectrum disorder (ASD), a population at risk of inactivity.

Objective: This cross-sectional survey study was designed to examine how neighborhood environmental factors and parental support are related to physical activity levels of children with ASD. Also, this study examined if the relationship between the environment and physical activity is modified by demographic factors and COVID-19 related concerns.

Methods: An online survey was completed by parents of children with ASD aged 10–17 years. The questionnaire included items related to environmental factors (i.e., distance to school, distance to park, existence of sidewalks, walkability), parent support for physical activity (i.e., encouraging, watching, and providing transportation), child's physical activity, and demographic characteristics. The instrument also queried parental concerns about COVID-19 and their child's physical activity participation.

Results: The results indicate that proximity to a local park and to school is positively associated with physical activity. Parent's encouraging behavior correlated with and predicted children's physical activity levels. Also, higher levels of COVID-19 related concerns among parents were related to decreased physical activity supporting behaviors.

Conclusions: This study demonstrated that the neighborhood environment, in particular the distance between home and parks and schools, and parent support behavior are influential factors that may shape physical activity behaviors for children with ASD.

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Regular engagement in physical activity can have a variety of physiological and psychological benefits for children, including improvements in improvements in blood cholesterol, blood pressure, obesity, bone density, and depression.¹ In addition, regular physical activity may provide some unique benefits for children with autism spectrum disorder (ASD), such as enhancing social and communication skills² and reducing stereotypical behaviors.³ Despite these benefits, physical activity participation levels among children with ASD tend to be low.^{4,5} For example, a review of accelerometer-measured physical activity levels among children with ASD based on 22 studies demonstrates that only 42% meet the

guidelines of 60 min of moderate to vigorous daily physical activity (MVPA) for children and adolescents aged 5–17.⁵ The researchers identified only two studies that reported all participants meeting the guidelines of 60-min per day in MVPA.⁵ When compared to children without ASD.

Since physical activity tends to decline among children in general⁶ as they get older,⁶ including among those with ASD,^{5,7} and unique characteristics of children with ASD may influence physical activity behaviors,^{2,3} it is necessary to understand the factors that impede or enable their participation. Due to the complex, multifactorial nature of physical activity determinants, researchers have turned to the social-ecological model as a means to conceptualize determinants of physical activity in this population.^{8–10} To date, this research has largely focused on individual, interpersonal, and organizational-level variables. Individual-level factors associated with physical activity among children

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with ASD include motivation^{11,12}; age^{13–15}; fitness levels¹⁶ and interpersonal-level factors, such as social support from peers and physical educators.^{17,18} Organizational factors, such as having adequate physical education and recess time,^{17,19} have also been identified as having influence over physical activity participation.

In addition to the aforementioned individual, interpersonal, and organizational-level variables, parent support for physical activity has also been recognized as being a key correlate of physical activity for children.^{20–23} Among children without ASD, specific parental support behaviors have been identified as being related to child physical activity, including parent–child co-activity, praising the child for being active, watching the child participate in physical activity, providing transportation, monitoring the child's activity levels, and supplying the child with physical activity equipment.^{20–23} Data, albeit limited, suggests that parental support for physical activity may also be related to physical activity among children with ASD. For example, a study²¹ surveyed 201 parents of children with ASD in Canada and revealed that parent physical activity support (intention and self-regulation for physical activity support) was related to physical activity behaviors of their children with ASD. However, to date, the specific parental support behaviors that are related to physical activity among children with ASD are unknown.

The social-ecological model of physical activity also suggests the built environment can constrain or encourage physical activity participation,^{24,25} and data gathered from children strongly support this concept.^{26,27} Systematic reviews and meta-analyses highlight how neighborhood walkability, active transportation infrastructure, and the availability of parks and playgrounds are important environmental determinants of physical activity levels of children without ASD.^{28,29} Photovoice¹⁰ and survey^{11,30} data from children with ASD and their parents suggest the built environment, such as the presence of parks, may be influential for physical activity among children with ASD also. Further research is required to test this perception. Perceptions of neighborhood safety have also been identified as being related to physical activity of children with ASD in some research,³¹ although other studies have revealed a lack of a significant relationship in this regard.³² There is an urgent need to comprehensively study how the environment relates to physical activity among children with ASD, including utilizing objective measures of proximity to neighborhood physical activity settings, such as parks.

Thus, the primary aim of this survey study was to examine how neighborhood environmental factors and parental support are related to physical activity levels of children with ASD. A secondary aim was to establish if the relationship between the environment (physical and social) and physical activity is modified by demographic factors. Moreover, as data were collected during the COVID-19 pandemic, the researchers sought to establish if parental COVID-related safety concerns were related to their support for their child's physical activity behavior.

Methods

Study design and recruitment

This study adopted a cross-sectional study whose data for were collected via an electronic survey administered to a purposeful sample of parents and guardians of children (aged 10–17 years) with ASD. The data were collected between October 2020 to January 2021. A link to the study survey was disseminated via email from organizations that serve individuals with ASD and their families, and via advocacy organizations' social media sites. For

example, advocacy groups from each state in the United States were contacted and asked to disseminate the study survey link via their social media pages. Parents/guardians were eligible to participate if they reported to be a parent or guardian of a child aged 10–17 years who had a diagnosis of ASD. Specifically, parents were eligible to participate in they responded “yes” to the question “has a doctor or other health care provider ever told you that your child has autism or autism spectrum disorder?” Participants who completed the survey were eligible to enter a draw for compensation for participation. The study protocol and materials were approved by the ethical committee of the third researcher's university.

Measures

The study survey, hosted on Qualtrics, included four sections (a) demographics of the child with ASD; (b) environment characteristics (including neighborhood, home, and parent support factors); (c) physical activity levels, and (d) COVID-related information. In total, the survey included 40 items.

Demographic questions

Eleven items queried demographic characteristics of the child with ASD, including level of ASD symptom severity (mild, moderate, severe), age, sex, living situation (lives with both parents, one parent, non-parent caretakers/guardians), number of children with and without ASD living in household, and diagnoses in addition to ASD (open-ended).

Environmental characteristics: Neighborhood

Three neighborhood environment variables were included (a) walking distance to the nearest park (distance to park), (b) walking distance to child's school (distance to school), and (c) neighborhood walkability score (walkability). To calculate these three variables, parents reported the zip code of the home in which the child lives and their school name. For distance to the park, each child's zip code was entered into google maps search bar, and the “nearby” feature was used to calculate the walking distance (in miles) to the park closest to the child's home. To calculate the distance between the child's home and school, the child's zip code and school name were entered into google maps and the walking distance (in miles) between both locations was calculated. This method has been previously used for the calculation of travel distances to nearby amenities, such as parks.^{33,34} The child's home zip code was also used to calculate their neighborhood walkscore®. The Walkscore provides an objective indicator of neighborhood walkability.³⁵ Finally, one question queried the presence of sidewalks in the child's neighborhood, via a question adopted from a previous study³⁶: “There are sidewalks on most of the streets in my neighborhood” (1, strongly disagree, to 4, strongly agree).

Environmental characteristics: Parental support

Parent support behavior for their child's physical activity was examined using three questions adopted from a previous study³⁷: (a) how many days do you or a household adult watch this child participate in sports or physical activity (days watching)? (b) How many days do you or a household adult encourage this child to do sports or physical activity (days encouraging)? And (c) How many days do you or a household adult provide transport to a place where this child can do sports or physical activity (days transporting)?

Physical activity

Physical activity was measured using a modified three-item Godin Leisure Time Questionnaire.^{38,39} The questions queried:

“During a typical 7-day period (a week), how many times on average does your child do the following kinds of exercise more than 15-min during their free time: (a) strenuous exercise (heart beats rapidly) (e.g., running, jogging), (b) moderate exercise (not exhausting) (e.g., fast walking, baseball, tennis), and (c) mild/light exercise (minimal effort) (e.g., yoga, easy walking).

Weekly leisure activity scores (leisure score) were calculated using the following formula: $(9 \times \text{Strenuous}) + (5 \times \text{Moderate}) + (3 \times \text{Light})$. Moreover, parents were asked how many days the child exercised, played a sport, or participated in physical activity for at least 60 min during the past week (Days PA 60 min). This item was derived from the National Survey of Children's Health (NSCH), a national survey of children's health administered annually by the U.S. Department of Health and Human Services.⁴⁰

COVID-19 safety concerns

As data was collected during the world-wide COVID-19 pandemic, the researchers added three questions to examine how COVID-19 influences parental perceptions of safety relating to physical activity: (a) I am concerned with my child's safety during physical activity, (b) I am more concerned with my child's safety during physical activity because of COVID-19, and (c) My concerns about safety during physical activity because of COVID-19 affects my child's physical activity. Respondents answered using a five-point Likert scale ranging from 1, not at all, to 5, totally.

Analysis

Data were extracted from the online survey platform to SPSS (version 28.0). Pearson correlation and simultaneous multiple regression were conducted to identify how variables were correlated with each other and what variables predicted children with ASD's physical activity variables (the leisure score and Days PA 60 min). For the regression, the assumption of normally distributed residuals was not met for leisure score, which was positively skewed. The data were log-transformed, resulting in normally distributed residuals. Because the logarithm is undefined for 0, leisure scores of 0 ($n = 9$) were not included in these analyses, therefore reducing the sample size.

In order to identify how higher or lower levels of COVID-related safety concerns among parents would relate to their physical activity support behavior, the researchers used two groups, one group with parents who reported no or little concern ($n = 43$) and another group with parents who reported moderate, mostly, and totally ($n = 48$), and ran a multivariate analysis of variance (MANOVA) to compare the two groups' support behavior. Also, Pearson correlation was used to detect significant relationships between parent support behaviors, child's physical activity variables, and COVID-related safety concerns. For any significant correlations identified in the regression analysis, the researchers ran a mediation analysis to identify ASD severity as a mediator using the PROCESS macro in SPSS (ver 3.5.3). A linear regression was conducted first and then the mediator was entered into the regression to check assumptions. The output for each mediation analysis included a test of X predicting M (path a), then X and M predicting Y (path b), and then X predicting Y (path c). Distance to park (X), leisure score (Y), and Days PA 60 min (Y) were entered in the analyses stepwise along with ASD severity (M) to test the significance of the mediator. Having other disabilities was a categorical variable, and thus, the researchers applied split file to separate groups (yes and no groups) to identify how having other disabilities change the correlations among variables that showed significance in the regression analyses. The level of significance was set at a p -value $< .05$ for all analyses.

Results

Child demographics and data reduction

Ninety-two respondents provided useable data for physical activity variables and demographic information. Table 1 shows demographic information on the respondents' children with ASD. There were missing data for the variables that queried the respondents' home address and child's school name, and thus, 64 respondents (69.5%) provided useable data for analyses for those variables. The researchers ran analyses to see if any significant differences in demographic characteristics would be found between the 64 and 92 respondents and confirmed there was no statistically significant difference.

Neighborhood factors and physical activity

Distance to park significantly associated with both physical activity variables including the leisure score ($r = -0.333, p = .006$) and Days PA 60 min ($r = -0.246; p = .036$). Also, the Days PA 60 min variable significantly associated with the leisure score ($r = 0.513; p < .001$). All other variables did not show significant correlations with physical activity variables. Simultaneous multiple regression showed that distance to school and distance to park explained a significant amount of the variance in the leisure score variable: $R^2 = 0.144, F(2,60) = 5.065, p = .009$. Distance to park was a significant predictor of the leisure score with a negative regression coefficient ($t = -3.163, p < .002$). Also, these variables explained a significant amount of the variance in Days PA 60 min variable: $R^2 = 0.103, F(2,64) = 3.677, p = .031$. Individual variables were not significant predictors of Days PA 60 min. The mediation analysis showed that none of the mediations were significant, meaning that ASD severity was not a mediator of any relationship between X and Y.

Parent support for physical activity

Simultaneous multiple regression identified the parents' physical activity support behavior explained a significant amount of the variance in the leisure score (Table 2): $R^2 = 0.101, F(3,80) = 3.009, p = .035$. No individual predictor had a statistically significant regression coefficient. Similarly, parents' physical activity support behavior explained a significant amount of the variance in the PA 60 min variable (Table 3): $R^2 = 0.281, F(3,88) = 11.483, p = .000002$. Days Encouraging was a significant predictor of the Days PA 60 min, with a positive regression coefficient ($t = 3.184, p < .002$).

The influence of COVID-19

The MANOVA showed that the parents' physical activity support behaviors were significantly different between the two groups of COVID-related safety concerns, $F(3,87) = 3.871, p = .012$, Wilks' $\Lambda = 0.882$ partial $\eta^2 = 0.118$. Tests of between-subjects effects revealed that the Days Encouraging variable only showed a significant difference between groups, $F(1,89) = 7.670, p = .007$, partial $\eta^2 = 0.079$. The group with little to no concerns ($n = 43$) reported 2.67 days for the Days Encouraging question whereas the group who responded moderate to totally ($n = 48$) reported 1.92 days. COVID-related safety concerns were negatively correlated with Days PA 60 min ($r = -2.91, p < .01$) and with Days Encouraging ($r = -0.407, p < .01$).

Table 1
Demographic variables

Variable	Frequency (in %)	Variable	Frequency (in %)
Total N	92		
Age	$M = 13.26$ ($SD = 2.210$)	Sibling	Yes = 43 (46.7%) With ASD = 17 (39.5%) Without ASD = 26 (60.4%) No sibling = 49 (53.3%)
Sex	Male = 70 (76.1%) Female = 22 (23.9%)	Severity	Mild = 34 (37.0%) Moderate = 44 (47.8%) Severe = 14 (15%)
Other disabilities	Yes = 52 (56.5%) No = 40 (43.4%)	Living with parent	Single parent = 18 (19.6%) Both parents = 72 (78.3%) No or other = 2 (1.1%)

Discussion

Ecological models of physical activity posit that a range of physical and social environmental factors shape physical activity behaviors.^{41,42} This study examined how environmental factors, including the neighborhood environment and parental support, were related to physical activity among children with ASD. Analyses of data from children with ASD showed that distance to school and to a nearby park, collectively, predicted leisure scores and days on which the child participated in 60 min of physical activity. Distance to park was independently a significant predictor of the time in leisure physical activity and ASD severity did not influence this relationship. Moreover, the parents' physical activity support behaviors together explained a significant amount of the variance in the leisure score and in the number of days of 60 min of physical activity. Notably, independent regression analyses showed that the number of days on which the parents encouraged physical activity significantly predicted the number of days the child engaged in at least 60 min of physical activity. Finally, COVID-related safety concerns were negatively correlated with the number of days of 60 min of child's physical activity and, pointing to a possible mechanism underpinning this relationship, parents with little to no concerns related to COVID-19 encouraged PA on significantly more days as compared to parents who reported to be moderately to totally concerned about COVID-19 in relation to their children's physical activity. These findings extend our understanding of how physical and social environmental factors are related to physical activity among children with ASD, and provide insight into the potential influence of COVID-19 on physical activity of children with ASD.

The environment plays a key role in shaping the physical activity opportunities available to children.^{43,44} For children without ASD, several studies point to a positive relationship between proximity to neighborhood parks and physical activity levels.^{45,46} Some data suggests that parks may be an especially important resource for families of children with ASD.^{10,11,30} For example, a photovoice study of 14 children with ASD revealed the presence of parks and playgrounds to be one of the most frequently reported facilitators to physical activity participation, noted by 45% of the sample.¹⁰

Similarly, a survey study of 103 parents of children with ASD saw almost a third of participants report that availability of affordable community programs or locations, including public parks, as being a critical factor in their child's level of engagement in and enjoyment of physical activity.¹¹ The current study provides further evidence of this relationship, documenting with more objective data of proximity to parks, and the importance of this setting for physical activity. Collectively, this evidence reinforces the importance of place-based initiatives and interventions, such as the development of accessible parks for groups at-risk of inactivity, such as children with ASD.

Moreover, interventions should consider the environment within which children with ASD reside and capitalize on local resources. For example, a study⁴⁷ demonstrated the feasibility of a web-based intervention that included providing the opportunity for parents to share information and photographs of local physical activities settings. Incorporation of local physical activity settings, such as parks, into physical activity interventions may increase the effectiveness and sustainability of interventions. However, being in close proximity to a physical activity settings may not always translate into more PA participation in children. Parents of children with ASD may not have knowledge and skills to promote their children's PA.⁴⁸ A recent study⁴⁹ explored parent-led intervention strategies to increase fundamental motor skills in children with ASD, and demonstrated that this type of intervention is feasible and effective. In summary, interventions that consider both local physical activity settings and the development of skills in children to actively use these settings (e.g., motor skills) may be optimal.

This study demonstrated that parent support behavior is an important factor that contributes to physical activity in children with ASD. This relationship is well-documented in studies of parent support behavior for children without ASD.⁵⁰ To the researchers' knowledge, only one study²¹ has reported parent support behavior as a significant predictor of children with ASD's physical activity. This study reinforces these findings and thus should encourage future research on parent support behavior for physical activity among children with ASD. In particular, this study reported parent encouragement for physical activity as a significant predictor of the

Table 2
Regression analysis predicting Leisure Score

Variable	Unstandardized coefficients		Standardized coefficients	t	p
	B	SE	Beta(β)		
Constant	2.785	.207		13.474**	<.000002
Days watching	.157	.096	.194	1.631	.107
Days encouraging	.143	.081	.213	1.758	.083
Days transporting	-.031	.091	.042	-.342	.733

Note: Constant = 2.785, $F(3,80) = 3.009^*$, $p = .035$, $R^2 = 0.101$.

Table 3
Regression analysis predicting days PA 60 min

Variable	Unstandardized coefficients		Standardized coefficients Beta(β)	t	p
	B	SE			
Constant	.641	.361		1.776	.079
Days watching	.342	.178	.202	1.918	.058
Days encouraging	.476	.149	.332	3.184**	.002
Days transporting	.201	.172	.125	1.167	.246

Note: Constant = 0.641, $F(3,88) = 11.483^{**}$, $p = .000002$, $R^2 = 0.281$.

number of days of which a child engaged in at least 60 min of physical activity. Future research should seek to deepen our understanding of how parents of children with ASD can best support and encourage their child's physical activity. Moreover, this study's data underpin the strategy of incorporating parents into interventions to increase physical activity among children with ASD, as demonstrated in recent studies.^{51,52} The current study did not show a correlation between the child demographic variables and parent support behaviors, with the exception of having other disabilities. Having other disabilities was significantly correlated with the number of days a parent spent watching their child engage in physical activity. This is understandable as there may be a need for parents of children with multiple disabilities to supervise their child's physical activity more than parents of children who have ASD only.

The COVID-19 epidemic has had profound effects on physical activity levels of children without ASD in the US,^{53,54} with some data suggesting a similar trend among children with ASD.^{55,56} This study sought to examine if parent concerns for COVID-19 and parent support behaviors may be one potential cause of this trend. Indeed, data showed that parents with higher COVID-19 related concerns for their child's physical activity participation tended to show lower support behaviors, especially fewer days on which they encouraged their child's physical activity. As fewer days on which parents' encouraged physical activity was negatively correlated with the numbers of days on which a child participated in at least 60 min of PA, this finding may point to a mechanism by which the COVID-19 pandemic influences physical activity of children with ASD. This may reflect prior parent-reported data which suggest children with ASD are faced with barriers to physical activity during COVID-19 despite of an awareness of benefits of physical activity.⁵⁶ The finding of this study may support the need to explore the dilemma parents of children with ASD experience during the COVID-19 as they balance their child's safety and physical activity.

Several limitations should be considered in interpreting and generalizing this study's findings. First, this study included a relatively small sample size. Moreover, several parents opted to not share their zip code/address and child's school name, thus further reducing the sample size for certain analyses. Second, this study was cross-sectional rather than longitudinal, and so the direction of the relationships cannot be ascertained. Third, several factors that may mediate the relationships between physical and social environments and physical activity of children with ASD were not examined. For example, to maintain a survey instrument that was not overly burdensome, the researchers did not query topics such as the number of siblings and parents in the child's household, active transportation amenities within the neighborhood (e.g. bike paths, sidewalks), and types of parks and park-use. In addition, this study did not take into account parents' physical activity and physical activity background (e.g., athletic background) although parent physical activity might be a factor associated with the child's physical activity.⁵⁷ Fourth, this was a survey study based on parent-report data; thus, some caution is

required when interpreting results. Of most importance, perhaps, future research is needed that incorporates objective measures of physical activity (e.g., accelerometer, pedometer). Finally, this study used google maps to identify the distances from the children's home to the nearest park and the child's school. Despite the use of this method in prior research^{33,34} the accuracy of this data is subject to the neighborhood features remaining unchanged since development of the google maps for each child's neighborhood. Tracking the movement of children with ASD using global positioning system (GPS) devices and assessing their physical activity using accelerometry may provide more reliable data on the contribution of local amenities, such as parks, to physical activity among children with ASD.

Conflicts of interest

All authors have no conflict of interest to report.

References

- Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Activ*. 2010;7(1):40. <https://doi.org/10.1186/1479-5868-7-40>.
- Chan JS, Deng K, Yan JH. The effectiveness of physical activity interventions on communication and social functioning in autistic children and adolescents: a meta-analysis of controlled trials. <https://doi.org/10.1177/1362361320977645>; 2020.
- Ferreira JP, Ghiarone T, Júnior CRC, et al. Effects of physical exercise on the stereotyped behavior of children with autism spectrum disorders. *Medicina*. 2019;55(10):685. <https://doi.org/10.3390/MEDICINA55100685>.
- Healy S, Aigner C, Haegele JA, Patterson F. Meeting the 24-hr movement guidelines: an update on US youth with autism spectrum disorder from the 2016 National Survey of Children's Health. *Autism Res*. 2019;12(6):941–951. <https://doi.org/10.1002/aur.2095>.
- Liang X, Li R, Wong SHS, Sum RKW, Sit CHP. Accelerometer-measured physical activity levels in children and adolescents with autism spectrum disorder: a systematic review. *Preventive Medicine Reports*. 2020;19:101147. <https://doi.org/10.1016/j.pmedr.2020.101147>.
- Lounassalo I, Salin K, Kankaanpää A, et al. Distinct trajectories of physical activity and related factors during the life course in the general population: a systematic review. *BMC Publ Health*. 2019;19:271. <https://doi.org/10.1186/s12889-019-6513-y>.
- Dahlgren J, Healy S, MacDonald M, Geldhof J, Palmiere K, Haegele JA. Physical activity and screen time among youth with autism: a longitudinal analysis from 9 to 18 years. *Autism*. 2021. <https://doi.org/10.1177/1362361320981314>. The International Journal of Research and Practice, 1362361320981314.
- Buchanan AM, Miedema B, Frey GC. Parents' perspectives of physical activity in their adult children with autism spectrum disorder: a social-ecological approach. *Adapt Phys Act Q (APAQ)*. 2017;34(4):401–420. <https://doi.org/10.1123/apaq.2016-0099>.
- Jones RA, Downing K, Rinehart NJ, et al. *Physical Activity, Sedentary Behavior and Their Correlates in Children with Autism Spectrum Disorder: A Systematic Review*. 2017. <https://doi.org/10.1371/journal.pone.0172482>.
- Obrusnikova I, Cavalier AR. Perceived barriers and facilitators of participation in after-school physical activity by children with autism spectrum disorders. *J Dev Phys Disabil*. 2011;23(3):195–211. <https://doi.org/10.1007/s10882-010-9215-z>.
- Obrusnikova I, Miccinello DL. Parent perceptions of factors influencing after-school physical activity of children with autism spectrum disorders. *Adapt Phys Act Q (APAQ)*. 2012;29(1):63–80. <https://doi.org/10.1123/apaq.29.1.63>.
- Pan CY, Tsai CL, Chu CH, Hsieh KW. Physical activity and self-determined motivation of adolescents with and without autism spectrum disorders in inclusive physical education. *Research in Autism Spectrum Disorders*. 2011;5(2):733–741. <https://doi.org/10.1016/j.rasd.2010.08.007>.

13. MacDonald M, Esposito P, Ulrich D. The physical activity patterns of children with autism. *BMC Res Notes*. 2011;4(1):422. <https://doi.org/10.1186/1756-0500-4-422>.
14. Pastor TG, Theirs JJSJ, Vicente DR. Obesity status and physical activity level in children and adults with autism spectrum disorders : a pilot study. *J Autism Dev Disord*. 2019;49(1):165–172. <https://doi.org/10.1007/s10803-018-3692-9>.
15. Wachob D, Lorenzi DG. Brief report: influence of physical activity on sleep quality in children with autism. *J Autism Dev Disord*. 2015;45(8):2641–2646. <https://doi.org/10.1007/s10803-015-2424-7>.
16. Tyler K, MacDonald M, Menear K. Physical activity and physical fitness of school-aged children and youth with autism spectrum disorders. *Autism Research and Treatment*. 2014;2014:312163. <https://doi.org/10.1155/2014/312163>.
17. Pan C-Y. Objectively measured physical activity between children with autism spectrum disorders and children without disabilities during inclusive recess settings in Taiwan. *J Autism Dev Disord*. 2008;38(7):1292–1301. <https://doi.org/10.1007/s10803-007-0518-6>.
18. Pan C. The efficacy of an aquatic program on physical fitness and aquatic skills in children with and without autism spectrum disorders. *Research in Autism Spectrum Disorders*. 2011;5(1):657–665. <https://doi.org/10.1016/j.rasd.2010.08.001>.
19. Sandt DDR, Frey GC. Comparison of physical activity levels between children with and without autistic spectrum disorders. *Adapt Phys Act Q (APAQ)*. 2005;22(2):146–159. <https://doi.org/10.1123/apaq.22.2.146>.
20. Yao CA, Rhodes RE. Parental correlates in child and adolescent physical activity: a meta-analysis. *Int J Behav Nutr Phys Act*. 2015;12(1). <https://doi.org/10.1186/s12966-015-0163-y>. BioMed Central Ltd.
21. Brown DM, Arbour-Nicotopoulos KP, Martin Ginis KA, Latimer-Cheung AE, Bassett-Gunter RL. Examining the relationship between parent physical activity support behaviour and physical activity among children and youth with autism spectrum disorder. *Autism*. 2020;24(7):1783–1794. <https://doi.org/10.1177/13623613202922658>.
22. Pyper E, Harrington D, Manson H. The impact of different types of parental support behaviours on child physical activity, healthy eating, and screen time: a cross-sectional study. *BMC Publ Health*. 2016;16:568. <https://doi.org/10.1186/s12889-016-3245-0>.
23. Wilk P, Clark AF, Maltby AM, Tucker P, Gilliland JA. Exploring the effect of parental influence on children's physical activity: the mediating role of children's perceptions of parental support. *Prev Med*. 2018;106:79–85.
24. Mcleroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. *Health Educ Behav*. 1988;15(4):351–377. <https://doi.org/10.1177/109019818801500401>.
25. Stokols D. Translating social ecological theory into guidelines for community health promotion. *Am J Health Promot*. 1996;10(4):282–298. <https://doi.org/10.4278/0890-1171-10.4.282>.
26. Ding D, Sallis JF, Kerr J, Lee S, Rosenberg DE. Neighborhood environment and physical activity among youth: a Review. *Am J Prev Med*. 2011;41(4):442–455. <https://doi.org/10.1016/j.amepre.2011.06.036>.
27. Huang JH, Hipp JA, Marquet O, et al. Neighborhood characteristics associated with park use and park-based physical activity among children in low-income diverse neighborhoods in New York City. *Prev Med*. 2020;131:105948. <https://doi.org/10.1016/j.ypmed.2019.105948>.
28. McGrath LJ, Hopkins WG, Hinckson EA. Associations of objectively measured built-environment attributes with youth moderate-vigorous physical activity: a systematic review and meta-analysis. *Sports Med*. 2015;45:841–865. <https://doi.org/10.1007/s40279-015-0301-3>.
29. Smith M, Hosking J, Woodward A, et al. Systematic literature review of built environment effects on physical activity and active transport – an update and new findings on health equity. *Int J Behav Nutr Phys Act*. 2017;14(1):1–27. <https://doi.org/10.1186/s12966-017-0613-9>. 2017 14:1.
30. Memari AH, Panahi N, Ranjbar E, et al. Children with autism spectrum disorder and patterns of participation in daily physical and play activities. *Neurology Research International*. 2015;2015:531906. <https://doi.org/10.1155/2015/531906>.
31. Fiscella NA, Case LK, Jung J, Yun J. Influence of neighborhood environment on physical activity participation among children with autism spectrum disorder. *Autism Res*. 2021;14(3):560–570. <https://doi.org/10.1002/aur.2445>.
32. Healy S, Garcia JM, Haegele JA. Environmental factors associated with physical activity and screen time among children with and without autism spectrum disorder. *J Autism Dev Disord*. 2020;50(5):1572–1579. <https://doi.org/10.1007/s10803-018-3818-0>.
33. Chiang YC, Li D. Metric or topological proximity? The associations among proximity to parks, the frequency of residents' visits to parks, and perceived stress. *Urban For Urban Green*. 2019;38:205–214.
34. Flowers EP, Timperio A, Hesketh KD, Veitch J. Examining the features of parks that children visit during three stages of childhood. *Int J Environ Res Publ Health*. 2019;16(9):1658.
35. Koohsari MJ, Sugiyama T, Hanibuchi T, et al. Validity of Walk Score® as a measure of neighborhood walkability in Japan. *Preventive Medicine Reports*. 2018;9:114–117. <https://doi.org/10.1016/j.pmedr.2018.01.001>.
36. Sallis JF, Kerr J, Carlson JA, et al. Evaluating a brief self-report measure of neighborhood environments for physical activity research and surveillance: physical Activity Neighborhood Environment Scale (PANES). *J Phys Activ Health*. 2010;7(4):533–540. <https://doi.org/10.1123/jpah.7.4.533>.
37. Tandon P, Grow HM, Couch S, et al. Physical and social home environment in relation to children's overall and home-based physical activity and sedentary time. *Prev Med*. 2014;66:39–44. <https://doi.org/10.1016/j.ypmed.2014.05.019>.
38. Godin G, Shephard RJ. A simple method to assess exercise behavior in the community. *Can J Appl Sport Sci*. 1985;10(3):141–146.
39. Shephard R. Godin leisure-time exercise questionnaire. *Med Sci Sports Exerc*. 1997;29(suppl 6):S36–S38. <https://doi.org/10.1097/00005768-199706001-00009>.
40. The U.S. Department of Health and Human Services. 2020 National Survey of Children's Health (NSCH) Codebook. Retrieved from <https://www.census.gov/data-tools/demo/uccb/nschdict>.
41. Spence JC, Lee RE. Toward a comprehensive model of physical activity. *Psychol Sport Exerc*. 2003;4(1):7–24. [https://doi.org/10.1016/S1469-0292\(02\)00014-6](https://doi.org/10.1016/S1469-0292(02)00014-6).
42. Sallis JF, Cervero RB, Ascher W, Henderson KA, Kraft MK, Kerr J. An ecological approach to creating active living communities. *Annu Rev Publ Health*. 2006;27:297–322. <https://doi.org/10.1146/annurev.publhealth.27.021405.102100>.
43. Aliyas Z. Assessment of the quality of place on park utilization (case study: 5 parks in different scales in bandar abbas). *Geography*. 2018;8(3):249–258.
44. Van Hecke L, Ghekiere A, Veitch J, et al. Public open space characteristics influencing adolescents' use and physical activity: a systematic literature review of qualitative and quantitative studies. *Health Place*. 2018;51:158–173.
45. Cohen DA, McKenzie TL, Sehgal A, Williamson S, Golinelli D, Lurie N. Contribution of public parks to physical activity. *Am J Publ Health*. 2007;97(3):509–514. <https://doi.org/10.2105/AJPH.2005.072447>.
46. Edwards NJ, Giles-Corti B, Larson A, Beesley B. The effect of proximity to park and beach use and physical activity among rural adolescents. *J Phys Activ Health*. 2014;11(5):977–984. <https://doi.org/10.1123/jphysicalactivityH.2011-0332>.
47. Healy S, Marchand G. The feasibility of Project CHASE: a Facebook-delivered, parent-mediated physical activity intervention for children with Autism. *Int J Disabil Dev Educ*. 2020;67(2):225–242. <https://doi.org/10.1080/1034912X.2019.1597968>.
48. Must A, Phillips S, Curtin C, Bandini LG. Barriers to physical activity in children with autism spectrum disorders: relationship to physical activity and screen time. *J Phys Activ Health*. 2015;12(4):529–534. <https://doi.org/10.1123/jpah.2013-0271>.
49. Columna L, Prieto LA, Beach P, Russo N, Foley JT. A randomized feasibility trial of a fundamental motor skill parent-mediated intervention for children with autism spectrum disorders. *Int J Environ Res Publ Health*. 2021;18(23):12398. <https://doi.org/10.3390/ijerph182312398>.
50. Edwardson CL, Gorely T. Parental influences on different types and intensities of physical activity in youth: a systematic review. *Psychol Sport Exerc*. 2010;11(6):522–535. <https://doi.org/10.1016/j.psychsport.2010.05.001>.
51. Healy S, Marchand G, Williams E. "I'm not in this alone" the perspective of parents mediating a physical activity intervention for their children with autism spectrum disorder. *Res Dev Disabil*. 2018;83:160–167. <https://doi.org/10.1016/j.ridd.2018.08.014>.
52. Esentürk OK, Yarımka E. WhatsApp-based physical activity intervention for children with autism spectrum disorder during the novel coronavirus (COVID-19) pandemic: a feasibility trial. *Adapt Phys Act Q (APAQ)*. 2021;1(aop):1–16. <https://doi.org/10.1123/apaq.2020-0109>.
53. Dunton GF, Do B, Wang SD. Early effects of the COVID-19 pandemic on physical activity and sedentary behavior in children living in the US. *BMC Publ Health*. 2020;20(1):1–13. <https://doi.org/10.1186/s12889-020-09429-3>.
54. Tulchin-Francis K, Stevens Jr W, Gu X, et al. The impact of the coronavirus disease 2019 pandemic on physical activity in US children. *Journal of Sport and Health Science*. 2021;10(3):323–332. <https://doi.org/10.1016/j.jshs.2021.02.005>.
55. Garcia JM, Lawrence S, Brazendale K, Leahy N, Fukuda D. Brief report: the impact of the COVID-19 pandemic on health behaviors in adolescents with autism spectrum disorder. *Disability and Health Journal*. 2020. <https://doi.org/10.1016/j.dhjo.2020.101021>.
56. Esentürk OK. Parents' perceptions on physical activity for their children with autism spectrum disorders during the novel Coronavirus outbreak. *Int J Dev Disabil*. 2020;1–12. <https://doi.org/10.1080/20473869.2020.1769333>.
57. Bringolf-Isler B, Schindler C, Kayser B, Suggs LS, Probst-Hensch N, the SOPHYA Study Group. Objectively measured physical activity in population-representative parent-child pairs: parental modelling matters and is context-specific. *BMC Publ Health*. 2018;18:1024. <https://doi.org/10.1186/s12889-018-5949-9>.