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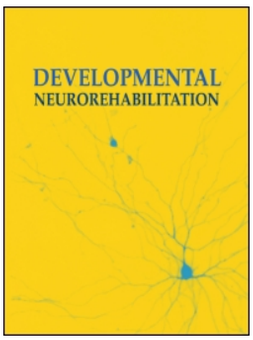

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Assessment of Walking Routes as a Possible Approach for Promoting Physical Activity in Children with Autism Spectrum Disorder: Brief Report

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ABSTRACT

Children with autism spectrum disorder (ASD) are at increased risk for being overweight/obese and face a variety of challenges with achieving the recommended levels of physical activity. Physical activity level has additionally been linked to motor skills, sleep, cognitive function and academic performance, and mental health in children with ASD. We pilot tested the feasibility and preliminary efficacy of walking routes as a novel approach to increasing physical activity among children with ASD. Physical activity was measured by accelerometry in 21 children ages 6–10 years. Participants received feedback on their physical activity and were counseled on using their surrounding neighborhoods to increase their physical activity. Non-completion (n = 9) reasons included equipment discomfort, family challenges, and diagnosis misattribution. While small changes in physical activity level and sedentary time were observed, neither was statistically significant. Further controlled studies on walking route interventions should continue to explore the potential benefits among this high-risk population.

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Autism; walking; physical activity; accelerometer; children; pilot

Introduction

Autism Spectrum Disorder (ASD) describes a range of chronic neurodevelopmental disorders characterized by difficulties with social interaction and communication as well as behavioral impairments including a tendency to engage in repetitive or restrictive behaviors.[1] ASD is common with an estimated prevalence of up to one in 59 children in the United States.[2] The risk of being overweight/obesity is higher and the tendency for physical inactivity is greater in children with ASD than in the general population – children with ASD have an adjusted odds ratio for obesity of 1.4 compared to the general population.[3–5] As in the general population, insufficient physical activity is thought to contribute to weight gain in children with ASD, along with poor dietary patterns including consumption of sugar sweetened beverages and calorie dense foods. Certain medications common prescribed in children with ASD have also been found to cause weight gain, including medications for mood control, seizures, attention, and certain classes of antipsychotic medications. Despite recent evidence that physical activity interventions improve a variety of outcomes in ASD,[6] physical activity levels remain low in children with ASD.[7] There are likely multiple reasons why children with ASD have lower physical activity rates than their peers, including social isolation, social anxiety, exclusion from activities, decreased motor skills and motor coordination, sensory sensitivities, executive function challenges, and difficulties with attention/focus.[8–10] These barriers contribute to an overall increased risk for weight gain and further complicating attempts at successful weight management in children with autism.[9] Classic sporting activities and environments traditionally used to promote physical activity in children, such as team sports and individual sports requiring a high degree of hand-eye coordination and independence may not be optimal and may create additional barriers for physical activity in children with ASD.[11,12]

Children with ASD may benefit from specialized approaches to managing physical activity that avoid the known physical activity barriers and which are specifically tailored to children with autism, namely by offering discrete physical activity opportunities that are limited in nature, safe, and specific.[13] Walking routes are discrete and achievable physical activity opportunities that have been shown to increase physical activity levels in typical youth,[14] and can overcome many of the physical and coordination barriers children with ASD face for more organized sports. Risk for elopement (wondering, running away from, or leaving a caregiving facility) is another ASD-specific barrier to outdoor physical activity, and accompanied walking can provide a safe opportunity for outdoor activity. Walking a specific route, repetitively is an activity which may be well suited for individuals with limited attention and across a broad range of cognitive abilities. Walking does not require advanced coordination or motor skills, there is no specific equipment necessary, and there are no transportation requirements thus it is a very accessible form of physical activity. While previous studies have looked at how physical activity affects the

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motor and executive functions of children with autism, there remains a paucity of data on the effectiveness of walking and on objectively measured physical activity in this population.[15] While a few studies have assessed walking in youth with ASD, some with improvements in physical activity, most studies used subjective physical activity assessment, sample sizes were often small with most studies including youth with ASD along with children with other developmental disabilities, and waking was often only one component of a larger intervention.[16–18] Importantly, these studies either assessed physical activity in the laboratory setting or used equipment or classes to promote physical activity, rather than one's existing surrounding neighborhood infrastructure. In previous studies in overweight and obese children and adolescents, we have demonstrated the benefits of using an individual's surrounding physical environments, including walking routes, as a tool to promote physical activity for typically developing youth.[14] Studies in children with ASD often require autism-specific approaches and tailored protocols, however, and in this study we therefore aimed to explore the feasibility of an adapted successful physical activity intervention to promote physical activity in overweight and obese children with ASD. We hypothesized that children with ASD would be capable of successfully participating in a walking route intervention, as determined by study enrollment, retention, and completion. We further hypothesized that among children who completed the walking route intervention, physical activity levels would increase and sedentary time would decrease compared to baseline.

Materials and Methods

Participants

We used hospital electronic health records to identify overweight/obese (Body Mass Index (BMI) ≥ 85th percentile) ambulatory children ages six to seventeen years diagnosed with ASD living in greater metropolitan Boston and followed at Massachusetts General Hospital, a major academic medical center in the northeastern United States. Informed parental consent and child assent were obtained for all participants. The study was approved by the Partners HealthCare institutional review board.

Study Protocol & Intervention

Eligible participants were mailed a study invitation letter introducing the study along with a picture book describing the study protocol prior to being contacted by a research assistant to inquire about the family's interest in participating in the study. Eligible participants were also encouraged to discuss the study protocol with their primary care and autism providers who were informed about the study prior to study initiation. After enrollment, families met with a research assistant to collect baseline measures. Physical activity data were collected over three separate one week periods (T1, T2, and T3). Baseline data collection were collected at the time of study enrollment (T1). After collecting and processing the baseline data, a member of the research team scheduled a counseling meeting (the intervention) with each participant and his/her family. Counseling sessions included the following elements: (i) providing feedback on the child's baseline physical activity level, (ii) providing a personalized map of the participant's home and school environment, (iii) collectively deciding on a personalized walking route for the participating child (Figure 1), designed as daytime walking routes lasting 30 minutes or more based primarily on the participant and family's answers to questions regarding their built environment (sidewalk availability, proximity to busy streets), and (iv) encouragement to use the walking route three or more times per week during the span of the intervention. Counseling sessions were scheduled individually as one hour meetings, at a time and location accommodating to participating families, including day and evening sessions, on

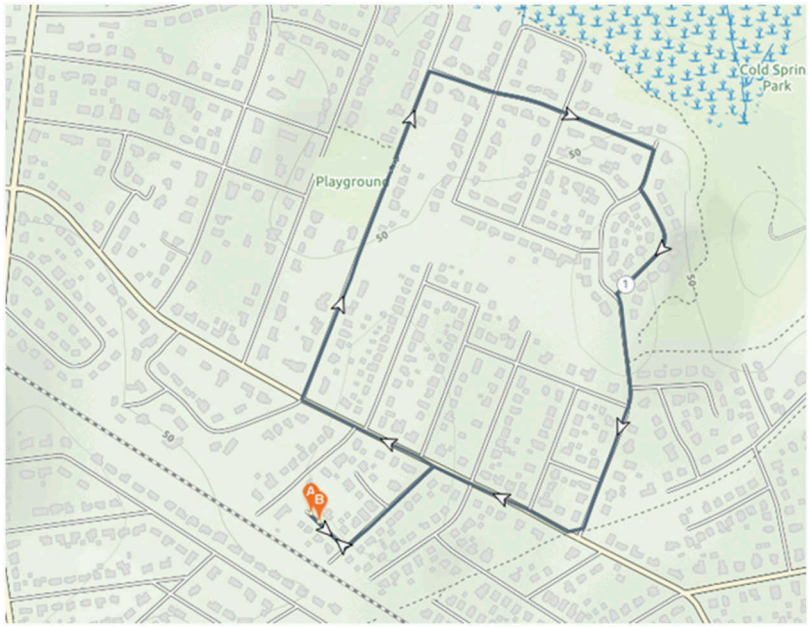

Figure 1. Example of assigned walking route around the home neighborhood.

campus or occasionally at the participant's home before or after school hours. Participants' caregivers were contacted 2–3 days following the meetings to assess adherence and answer questions. Participants were then asked to provide two additional physical activity data samples, one immediately following the intervention (T2), and then again three months after receiving the intervention (T3). A study team member met the family after each data collection period to collect the study equipment. Upon returning the equipment after the final data collection period, families received $50 in remuneration for study participation.

Measures and Outcomes

Feasibility

Study feasibility was assessed as enrollment and retention. Enrollment feasibility was calculated as the number of study participants over the number of participants identified as eligible for the study. Retention feasibility was calculated as the number of participants who completed the study by providing physical activity data at all three time points over the number of enrolled participants. Feasibility was defined a priori as achieving 50% or greater for both enrollment and retention.

Anthropometric Data

Height and weight were measured at baseline and again at study conclusion by trained research staff using a stadiometer (SECA, HANOVOVER, MD) and digital scale (LifeSource MD; A&E Engineering, Inc., San Jose, CA), with indoor clothes, shoes removed, and pockets emptied. Height and weight were measured twice, then averaged. BMI was calculated using age- and sex-specific CDC growth curves.

Physical Activity

Each participant's objective physical activity was measured using an ActiGraph wGT3x-BT wireless accelerometer worn on an elastic belt around the waist while awake except during water activities and contact sports. Equipment wear time was collected to provide an objective assessment of participant engagement and to help determine study feasibility. Accelerometers were initialized to collect data every 30 seconds. Pediatric specific thresholds classified sedentary time as <100 activity counts per minute and moderate-to-vigorous physical activity (MVPA) as ≥ 2,296 counts per minute.[19,20]

Analyses: Study sample characteristics and baseline data are reported using descriptive statistics. Study feasibility was assessed via enrollment percentage, study retention, and equipment wear time using descriptive statistics. Short-term (T1-T2) and longer-term (T1-T3) changes in mean daily MPVA and sedentary time (ST) were calculated for each participant.

Results and Discussion

Thirty-six children were identified and initially expressed interest in participating; we were subsequently unable to reach four after initial contact, eleven declined completing the screening questionnaire, and 21 consented to participate in the study. Of these twenty-one participants, nine dropped out of the study, leaving twelve participants enrolled who completed the study. Reasons for attrition after enrollment included: unable to tolerate wearing the study equipment (6), equipment loss (1), complex family situation (1), medical misdiagnosis (1). A four-month study period was initially planned but required eighteen months to complete; reasons for delay included repeat data collection periods due to insufficient data or accelerometer malfunction on initial data collection attempt, delayed equipment return, and scheduling challenges with families.

Baseline demographic data for the 12 children participating in the study who provided data at T1, T2, and T3 are presented in Table 1, with detailed information on each participant's demographic and clinical data provided in Table 2. Participants provided 250 days of valid activity data, of which 192 (77%) were weekdays. Mean accelerometer wear times were 728, 701, and 731 minutes at T1, T2, and T3, respectively. After receiving counseling, the average change in mean daily MVPA increased from baseline by 2.9 minutes a day (Standard Deviation (SD) = 14.3, p = .5) (6.3% increase from baseline), and remained elevated compared to baseline at three months (increase of 12.7 minutes of MVPA/day, SD = 39.5, p = .3), however these upward trends did not meet conventional levels of statistical significance. Mean daily sedentary time decreased after receiving the intervention by 9.8 minutes a day (SD = 58.2, 2.4% decreased from baseline, p = .6), and increased from baseline at three months (increase of 3.1 minutes of ST/day, SD = 83.8, p = .9), and likewise these trends were not statistically significant. The participants' individual data are reported in the Supplementary Figure. Mean change in BMI percentile at three months was −0.7 (p = .6).

In this pilot intervention study among children with autism who are also overweight or obese, we explored the use of walking trips to promote physical activity. We successfully enrolled over half (58%, 21/36) of eligible identified children and likewise over half (57%, 12/21) of enrolled participants completed the study, suggesting feasibility. Significant time delays related to the challenges of collecting valid objective data in this population, however, resulted in the study running more than four times longer than originally anticipated. Of the twelve participants who completed the study, accelerometer wear time remained consistently high throughout the study, suggesting reasonable study protocol adherence.

Table 1. Study sample characteristics, baseline (n = 12).

	Values
Age, years (SD)	11.4 (3.3)
Male, %	67
Race/ethnicity, %	
White	50
Black	8
Asian	8
Multi/other	34
Hispanic/Latino	42
BMI percentile, mean	94.3
MVPA, mean minutes/day	46.2
Sedentary time, mean minutes/day	412.7
Total wear time, mean minutes	727.8
Parental Education, %	
High school or less	9
Partial college or college	58
Graduate education or beyond	33

BMI = body mass index; MVPA = moderate-to-vigorous physical activity

Table 2. Participant characteristics.

Child	Age (years/months)	Sex	Race	Ethnicity	Parent Education	Baseline BMI percentile	Follow-up BMI percentile
1	6/3	Male	White	Hispanic/Latino	College	95	83
2	8/8	Female	Multi/Other	Hispanic/Latino	High School	95	97
3	10/3	Male	White	Hispanic/Latino	Partial College	98	97
4	7/0	Male	Multi/Other	Hispanic/Latino	College	91	94
5	12/6	Female	White	Non-Hispanic/Latino	College	98	98
6	9/7	Female	Multi/Other	Hispanic/Latino	Partial College	84	78
7	16/7	Male	White	Non-Hispanic/Latino	College	98	99
8	12/8	Male	African-American	Non-Hispanic/Latino	Graduate School	99	99
9	14/6	Female	Asian	Non-Hispanic/Latino	Graduate School	79	83
10	15/5	Male	Multi/Other	Non-Hispanic/Latino	Graduate School	99	99
11	15/3	Male	White	Non-Hispanic/Latino	Graduate School	97	98
12	12/7	Male	White	Non-Hispanic/Latino	Partial College	98	98

Changes in MVPA levels were not significantly different after the intervention. This is not unexpected given the small sample size. Despite not reaching statistical significance, trends were observed in health-enhancing MVPA behaviors. Although the absolute gains in MVPA among individuals were small and the clinical significance of increasing daily MVPA by three minutes is modest, achieving a six percent shift in the health-enhancing physical activity levels of a high-risk group through a low-cost and easy to implement intervention could potentially be important on a population level. Despite incorporating ASD-specific adaptations such as the use of a picture book and focusing on walking routes as the outdoor physical activity, however, disease-specific challenges emerged during the study. Sensory issues involving belt discomfort were the most common reason for not tolerating accelerometer-based physical activity measurement, highlighting the importance of finding ASD-friendly ways of collecting objective physical activity data in this high-risk population. Traditional waist-worn elastic belts may not be ideal in ASD given the prevalence of sensory issues, while wrist-worn devices are likewise not ideal as they provide falsely elevated values due to stereotypic hand flapping movements common in children with ASD. Novel approaches to accelerometry, such as the use of devices that are incorporated into clothing may be preferable, and further studies assessing optimal methods for accelerometry data collection are necessary in this high-risk population.

Importantly, we also discovered that family availability and commitment is an important factor for outdoor walking studies as participants with ASD typically required companionship, even with walking routes restricted to their immediate neighborhoods. Families reported that financial incentives did not motivate their children with ASD to meet the recommended walking goals, despite proving an effective tool for promoting study adherence and goal setting in a similar prior walking intervention in the general population.[14] Similar to prior studies, our sample size was small and we observed marginal changes in our walking behavior and BMI outcomes.[13,17]

This pilot study included a small sample size and did not include a control group. Families did not receive real-time feedback on their child's physical activity level, a technique which has been shown to motivate behavior change. We likewise did not directly assess whether participants completed the recommended walking routes, we only measured physical activity levels. Our follow-up measures of physical activity were collected at 3 months, and longer term follow-up at one or two years can offer additional insight when assessing sustainable changes in health behaviors. Even without a comparative control group the finding of a trend towards improved BMI is encouraging, given the known tendency of BMI to increase over time.

This novel study used objective physical activity measurement to test a real-life approach to increasing physical activity among a population that faces multiple barriers and challenges to energy balance. To our knowledge, this is the first study that has tested using walking trips as a means to increase physical activity in children with autism who are obese or overweight. Walking trips represent a discrete and achievable form of physical activity in people with ASD, and our feasibility and preliminary efficacy data suggests that empirically testing the use of walking routes to promote health-enhancing physical activity and limit sedentary time in children with ASD merits further study.

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Declaration of Interests

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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