ARTICLE

Acceptability and Feasibility of Examining Physical Activity in Young Children with Type 1 Diabetes

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ABSTRACT

Physical activity is important but may be difficult to evaluate in young children (YC) with Type 1 diabetes (T1D) because of parents' fears of hypoglycemia, difficulties engaging YC in physical activity, and use of assessment devices. This study aimed to explore the acceptability and feasibility of an in-lab exercise session for YC with T1D. Ten YC ages 3 through7 years with T1D participated in a 20-minute exercise session while wearing blinded continuous glucose monitors and accelerometers. High acceptability was found for participation in the exercise session; high feasibility and acceptability were reported for the assessments. Although most children completed the session, it did not produce moderate to vigorous physical activity. YC were found to spend most of their day sedentary, and they had frequent blood glucose excursions. Findings support the feasibility of conducting a more extensive examination of the relationship among blood glucose levels and physical activity in YC with T1D. J Pediatr Health Care. (2017) ■■, ■■-■■.

KEY WORDS

Exercise, physical activity, research methods, type 1 diabetes, young child

The incidence of Type 1 diabetes (T1D) is increasing, with the most rapid growth in young children (< 5 years; Dabelea et al, 2014). The American Diabetes Association recommends a target hemoglobin A1c level less of less than 7.5% for youth (American Diabetes Association, 2017), yet most have difficulty meeting this goal (Wood et al, 2013), and adequate diabetes management likely requires even more vigilance for parents

of YC (Streisand & Monaghan, 2014). Improvements in A1c level are associated with regular physical activity (PA; Schwab et al., 2016), although this relationship has been less clear in younger children (Leclair, De Kerdanet, Riddell, & Heyman, 2013). As parents strive to maintain within-range blood glucose (BG) levels (90-150 mg/dl is the recent recommendation by the American Diabetes Association (2017) for all youth younger than 19 years), they may consider PA as one important tool to help curb high BG levels. Despite well-known, long-term benefits of PA, the potential for acute effects of BG levels decreasing to an unsafe level during PA warrants further study (Leclair et al., 2013). YC are at particularly high risk of acute glycemic excursions given their difficulty detecting and communicating hypoglycemia symptoms, which has been associated with a threefold increase in mortality (Franchini, 2016). In experimental studies, youth with T1D who engaged in afternoon PA have been found to have a 38% to 80% higher risk of nocturnal hypoglycemia (Bachmann, Hess, Martin-Diener, Denhaerynck, & Zumsteg, 2016; Metcalf et al., 2014), and close BG monitoring for 72 hours after PA has been recommended (McMahon et al., 2007). However, meta-analyses of PA interventions in youth with T1D report few instances of hypoglycemia (Wu, Thompson, Aroian, McQuaid, & Deatrick, 2016), and studies with adults suggest that minor increases in hypoglycemia can be addressed with insulin adjustments before the start of PA (Chimen et al., 2012).

There are several limitations to the existing literature on PA in children with T1D. Many studies have had a primary focus on adolescents, used nonobjective measurements of PA, or failed to capture the time-sensitive impacts of PA on BG (Tully, Aronow, Mackey, & Streisand, 2016). More research is needed to determine if models of BG variability built on adolescents and adults apply to YC, whose PA engagement often occurs throughout the day in bursts rather than in discrete periods of time (Ruiz, Tracy, Sommer, & Barkin, 2013). Furthermore, little is known about the best method to measure the activity patterns of YC with T1D and the immediate impact of YC's PA levels on their BG regulation. Finally, because parents may avoid intensive PA for their child because of their own hypoglycemia fears, (Jabbour, Henderson, & Mathieu, 2016) the feasibility of conducting an experimental exercise session in YC with T1D is unknown.

The primary aim of this study was to determine the feasibility of measuring PA of YC with T1D in a laboratory setting and home. Secondary aims were to conduct preliminary explorations of the relationship between BG and PA, with the goal of hypothesis generation regarding future larger investigations and intervention targets for improving glycemic control. The exercise session and a naturalistic observational period using objective measures of BG and PA are described.

METHODS

Ten children (mean [*M*] age = 5.88 years, 80% female, *M* ± standard deviation [*SD*] A1c level = 7.32% ± 0.50) with T1D for at least 1 year (*M* ± *SD* duration = 2.78 ± 1.55 years) participated. Children were White (60%), African American (20%), and Hispanic/Latino (20%). Parents were all married (90% mothers) and predominantly had a 4-year college degree (90%). Eight children used a basal-bolus regimen; two were on fixed-dose conventional insulin regimen. Parents checked their children's BG levels an average of 6.70 ± 2.29 times/day by BG monitoring. The study was conducted at a pediatric academic medical center in the mid-Atlantic region of the United States, and all procedures were approved by the institutional review board.

Each child and parent attended a study visit at the clinical research center. After arrival, the research nurse measured height and weight and inserted a blinded continuous glucose monitor (CGM; iPro, Medtronic, Northridge, CA) on the children, who were also fit with wrist accelerometers. Evidence supports wrist placement of the accelerometer used in this study with YC (Johansson, Ekelund, Nero, Marcus, & Hagströmer, 2015). Parents were instructed to calibrate four times a day with BG meter readings. After CGM insertion, children were engaged in sedentary behaviors while parents completed questionnaires, and then the family ate lunch in the hospital cafeteria. Two hours after lunch, if the child's BG level was between 100 and 200 mg/dl, the child participated in 20 minutes of a developmentally appropriate PA of their choice: a dancing game (*Just Dance for Kids* for Nintendo Wii, Nintendo, Kyoto, Japan) or a preschool exercycle (Fisher-Price Smart Cycle, Fisher-Price, East Aurora, NY). Games were selected for appeal to children of this age and prior use in PA programs (Gao, Chen, Pasco, & Pope, 2015). Children were monitored for any signs of hypoglycemia via CGM and visually during and for 1 hour after the exercise session. If needed, children with lower BG level (< 100 mg/dl) were given a 15-g carbohydrate snack, and BG levels were monitored until in an acceptable range (≥ 100 mg/dl) before children were discharged. A summary of the CGM findings was offered to families at the conclusion of the study and given to the physician, with permission.

Accelerometers were used to measure accelerations or gyrations and provide information as to the initiation, duration, and magnitude of movement during daytime activities (Ambulatory Monitoring Inc., Ardsley, NY). Accelerometer counts were recorded at 1-minute intervals throughout the 5-day period. Time-stamped activity data were categorized as *moderate-to-vigorous physical activity (MVPA)* if energy expenditure was greater than 0.04 kcal/kg/minute and as *vigorous-intensity PA* if activity energy expenditure was greater than 0.10 kcal/kg/minute (Maslow & Colabianchi, 2011). This corresponded to accelerations as follows: seden-