THE MEDIATING ROLE OF GLYCEMIC CONTROL ON PHYSICAL ACTIVITY AND INTERNALIZING AND EXTERNALIZING BEHAVIORS IN YOUTH WITH TYPE 1 DIABETES MELLITUS

by

Cassandra A. Hicks

A Dissertation Submitted to the Faculty of the

DEPARTMENT OF DISABILITY & PSYCHOEDUCATIONAL STUDIES

In Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

2021

2

THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

As members of the Dissertation Committee, we certify that we have read the dissertation prepared by: Cassandra A. Hicks
titled:

and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

Michelle Perfect Date: Aug 19, 2021
Michelle Perfect

JMK, PhD Date: Aug 21, 2021
Jennifer Kirkpatrick

Jina Yoon Date: Aug 20, 2021
Jina Yoon

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copies of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

Michelle Perfect Date: Aug 19, 2021
Michelle Perfect
Dissertation Committee Chair
Disability and Psychoeducational Studies

ACKNOWLEDGEMENTS

I have such appreciation to my committee chair, Dr. Michelle Perfect. The completion of this dissertation would not have been possible without the commitment and encouragement you provided me throughout this process. Thank you for being a driving force and believing in me. I am fortunate to have had the opportunity to work with you. I would also like to thank my committee members, Dr. Jina Yoon and Dr. Jennifer Kirkpatrick. I appreciate the feedback you provided me.

Thank you to my friends and family. I cannot express enough gratitude to each of you for your support and encouragement. Graduate school introduced me to life-long best friends. Katie, Kenna, and Malo, I am thankful that we shared this experience together. Mr. C, you have been such an incredible figure in my life; thank you for stepping up the way you have. Ryan, thank you for your steady presence in my life and your continued dedication to me. You and your family inspire me to be the best version of myself. Thank you to my pup Topher, who always puts a smile on my face and has been the best writing buddy I could have asked for. Mom, thank you for all the sacrifices you made in allowing me to pursue an education. You taught me about hard work and strength, and it has gotten me to where I am today. Elliott, you have inspired me to continue reaching for my goals, teaching me that nothing is impossible. I have always valued your pride in my accomplishments. Wyatt, the family you have built fills me with such happiness. Thank you for being a lifelong best friend and having a heart that always understands my own. Finally, to my father, who inspired all of this. I will forever aim be like you.

DEDICATION

Mom and Dad, this is for you.

Table of Contents

List of Figures

List of Tables

ABSTRACT

Research has documented a higher prevalence of psychiatric conditions and emotional difficulties in youth with Type 1 Diabetes Mellitus (T1DM). Routine screening across a range of social-emotional and behavioral symptoms is recommended by the American Diabetes Association (ADA) Standards of Care. Despite these documented behavioral challenges in youth with T1DM, there is a lack of research about how teachers view these behaviors manifesting in school. Further, more research is needed to understand possible links between glycemic control and school behavior. The purpose of this study was to examine the mediating role of glycemic control on physical activity and teacher-reported internalizing and externalizing behaviors. There were three research questions with the first focusing on the relative contribution of different metrics of glycemic control in predicting two internalizing (anxiety and depression) and three externalizing (hyperactivity, aggressivity, and conduct problems) behaviors. Additionally, questions two and three examined the relations between physical activity and teacher-reported behaviors along with the mediating role of glucose in that relationship. The findings showed that glycemic regulation measured via continuous glucose monitoring (CGM) contributed greater variance than HbA1c. Certain glucose metrics shared a significant relation with anxiety and depression symptoms but did not relate to externalizing behaviors. CGM averages across a week were most predictive of teacher-reported behaviors, as they showed significant bivariate relations with multiple Behavior Assessment System for Children, Second Edition, Teacher Rating Scales (BASC-2 TRS) scores, meaning that difficulties with disease management and behavioral functioning in school co-occur. Although the effects were small, glycemic control was also related to students' internalizing symptoms, learning challenges, study habits, and attention. Physical activity did not relate to teacher-reported behaviors, and although high

glucose levels positively related to more internalizing symptoms, there seemed to be direct associations rather than these subscales serving as mediators. Future research is also suggested, including the exploration of how real-time momentary changes in glucose levels are associated with behaviors in the classroom.

Chapter 1: Introduction

Statement of the Problem

Type 1 Diabetes Mellitus (T1DM), which has been called juvenile-onset diabetes mellitus and insulin-dependent diabetes mellitus, is the third most common chronic disease in childhood and continues to rise worldwide (Dabelea, 2009; Pettitt et al., 2014; SEARCH for Diabetes, 2006; Wyckoff et al., 2015). Worldwide, diabetes is increasing by 2-5% annually (Maahs et al., 2010). In youth aged 0-14 in the United States, the incidence of T1DM is 28.0 per 100,000 individuals per year and that number is increasing by 2.7% annually. In all cases of diabetes worldwide, T1DM accounts for 5-10% of the cases (Maahs et al., 2010; You & Henneberg, 2016).

T1DM is an autoimmune disease caused by the pancreas' deficient insulin production. According to the Centers for Disease Control and Prevention (CDC, 2020), in T1DM, the insulin producing cells in the pancreas are damaged. The damage limits or destroys the production of insulin, which is the hormone needed to lower blood glucose levels. T1DM was once life threatening. However, with the medical advances in insulin therapy, people with T1DM can now anticipate that the disease will not be fatal if well controlled (Leclair et al., 2013). Even so, due to the body's inability to produce insulin, treatment for T1DM is lifelong. Treatment includes daily injections or insulin pump therapy to adjust insulin and maintain appropriate blood glucose levels (Long & Bingley, 2009; Marks et al., 2013). This treatment is required for survival (CDC, 2020). Individuals with TIDM need to adjust their insulin based on their glucose levels, food intake (specifically, carbohydrates), and activity level (Leclair et al., 2013).

Two-thirds of youth with T1DM evidence poor diabetes control due to poor treatment adherence (McGrady et al., 2014). Diabetes control is important because of the short-term and long-term health effects associated with TIDM. According to the American Diabetes Association's (ADA) Standards of Medical Care (Standards) hyperglycemia can occur if the blood glucose levels are too high, which can lead to frequent urination, high levels of sugar in urine, dry mouth, and ketoacidosis (diabetic coma; ADA, 2020). Ketoacidosis is a very serious condition and symptoms can include trouble breathing, nausea, vomiting, dry mouth, and a fruity smell of the breath. Hypoglycemia can occur if the blood glucose levels are too low which can lead to seizures, unconsciousness, and, in severe cases, death (CDC, 2020). Poor diabetic control, problems in school, stress at home (single-parent families), low socioeconomic status, and no health insurance can aggravate the risk of these short-term complications (Rewers et al., 2002). Long-term effects can include thyroid disease, celiac disease, high blood pressure, heart disease and stroke, blindness and eye problems, kidney disease, neuropathy, loss of limbs, and decreased life expectancy (ADA, 2020; CDC, 2020). Due to these long-term effects, TIDM treatment requires screening for related complications (Daneman, 2006). One of the leading causes of blindness, end-stage renal disease, and neuropathy, is diabetes (Cooke & Plotnick, 2008).

Glucose levels can be measured by a blood glucose meter, a continuous glucose monitor (CGM), and a glycated hemoglobin (HbA1c) blood test. Glucose should be measured 6-10 times per day (ADA, 2020). A blood glucose meter provides a reading of the blood glucose in that moment. The meter is used by placing a drop of blood on a strip and putting it into the meter. The meter then reads the blood glucose level and displays the reading. A CGM also offers a real-time measurement of glucose levels throughout the day. The CGM is placed under the skin and continuously monitors glucose levels. The target range for blood glucose levels ranges between 70-140 mg/dL, with suboptimal levels from 141-179 mg/dL (Knight & Perfect, 2019). A HbA1c blood test offers a 3-month average of blood glucose levels (ADA, 2020). HbA1c levels should be <7.5%, although levels are based on each individual's treatment plan (ADA, 2020). ADA's Standards comprise a series of sections that address the continuum of care for individuals with diabetes from diagnostic features, assessment of co-morbidities, treatment recommendations, and additional clinical guidelines related to appropriate follow-up support (2020).

Although HbA1c testing is a critical figure for diabetes management, it can be too general to be linked with daily influences and changes across settings, in shorter time frames throughout the day. The daily fluctuations in glycemic control are not captured by HbA1c levels. With CGM's, levels are recorded every five minutes. Patton et al. (2011) suggested that with the use of CGM, researchers can explore how daily or weekly metrics of glycemic control can be used in behavioral research to understand connections between glycemic control and psychosocial functioning. With the more detailed information provided by CGM measures, researchers can analyze links between glycemic control and behavior (Patton et al., 2011).

Internalizing and Externalizing Behaviors in T1DM

A link has been shown between poor glycemic control and behavior problems (Cohen et al., 2004). Children diagnosed with T1DM who exhibit internalizing and externalizing behaviors have poorer glycemic control (Cohen et al., 2004; Herzer & Hood, 2009). Maas-van Schaaijk et al. (2013) examined social-emotional problems in adolescents with T1DM and found that glycemic control was related to both internalizing and externalizing behaviors, namely in depression and rule-breaking behavior. Ahmed et al. (2016) examined psychosocial and behavioral characteristics of youth with T1DM. The authors found that 92.9% of participants with T1DM endorsed experiencing emotional, conduct, hyperactivity, and peer relation problems. In comparison, 20.6% of controls endorsed having these difficulties. Anecdotally, parents have reported that changes in their child's behavior alerts them to a possible spike in their blood glucose level (McDonnell et al., 2007). Despite, these linkages between glycemic control and behaviors based on self- and parental report, limited data is available regarding teachers' perceptions of the manifestation of social-emotional challenges at school (Amillategui et. al., 2007).

Physical Activity in T1DM

According to the ADA (2020), physical activity is defined as increased energy use through movement. Gardening, walking up/downstairs, and vacuuming constitute physical activity. Included in physical activity is exercise, which is planned, structured, and improves physical fitness. Examples of exercise include running, biking, and going to the gym to lift weights. In school-age youth, it is recommended to engage in at least 60 minutes of moderate to vigorous physical activity daily (Strong et al., 2005). The same recommendations are made for youth with TIDM, as they should also participate in at least 60 minutes of moderate to vigorous aerobic activity every day, with muscle- and bone-strengthening activities performed three days every week (ADA, 2020). Engaging in the recommended level of physical activity promotes disease-prevention (Strong et al., 2005). Consistent physical activity is a crucial routine in improving overall health (Michaliszyn & Faulkner, 2010). Data have shown the beneficial effects of physical activity on musculoskeletal health, cardiovascular health, adiposity in those who are overweight, and blood pressure in youth with mild hypertension (Strong et al., 2005). Additionally, exercise can improve mood and self-esteem and can reduce anxiety and depression (Biddle & Asare, 2011; Peluso & Guerra de Andrade, 2005).

In a systematic review, Quirk et al. (2014) summarized the physical and psychosocial benefits of physical activity for children with T1DM, including improved cardiovascular health, healthy weight, improved bone health and self-confidence, and developing social skills. Research has demonstrated, however, that youth, including those with TIDM, do not achieve sufficient levels of physical activity needed to gain access to the accompanying benefits. Since individuals with TIDM are already at risk for increased cardiovascular disease, the importance of physical activity is heightened (Quirk et al., 2014).

Addressing diabetes management is not just about the medical treatment of diabetes, but also about how glycemic control influences behaviors. As noted above, although physical activity is not a core treatment for T1DM, there are physiological and psychosocial benefits that can have positive effects on individuals. However, the link between physical activity and behavior in youth with T1DM in the school context, with teachers as informants, has not been explored in the literature.

T1DM in School

Some published literature has described the self-care needed to effectively manage diabetes throughout the school day (Amillategui et. al., 2007). Students spend about 1/3 of a day at school. During the school day, diabetes treatment entails meal planning, glucose testing, and possible insulin injections (Amillategui et. al., 2007; Marks et al., 2013). To incorporate these management activities, students may need support for school personnel (Amillategui et al., 2009. The studies that do exist can be difficult to generalize the findings on behavioral difficulties because the data are based on self- or parent- reports. For example, one study used nurses as informants, to which they noted that they believe students with T1DM need more support at school (Nabors, et al., 2005). Another study used parents as informants (Amillategui, et al., 2007). Hayes-Bohn et al. (2004) used both parent and student informants.

Teachers interact and observe the students at different times and varying contexts, and it is not known how glucose levels may temporarily relate to the behaviors observed by teachers.

School personnel could feasibly track glycemic levels of students with T1DM (and in some cases, already are) and monitor student's social emotional functioning and overall health behaviors and how those present in the school setting.

Significance of Current Study

This study aimed to look at the relations between different metrics of glycemic control and teachers' reported internalizing and externalizing behaviors of youth with T1DM. In addition, it examined the direct impact of physical activity on internalizing and externalizing behaviors and the mediating role between physical activity and internalizing and externalizing behaviors. Physical activity can improve mental well-being (Goldstein et al., 2020), results in better overall health outcomes (Penedo & Dahn, 2005), and extends lifespan (Paluska & Schwenk, 2000). Bohn et al., (2015) found that engaging in physical activity had an inverse relationship with glucose levels. Although the behavioral challenges in youth with T1DM are known, there is a lack of research in schools examining behavioral and social-emotional functioning in youth with T1DM, especially using teachers as informants (Amillategui et. al., 2007). With the advancement in technology allowing real-time assessment of blood glucose levels, there is a practical significance in examining how glycemic control impacts behavior in youth with T1DM within a narrow time frame. Not only could this research provide a better understanding of any link between acute glycemic control measures and school behavior, but it could also improve the overall health of a child, as dysregulated glucose over time can ultimately lead to significant complications or loss of life (Healy et al., 2007).

Research Questions and Hypotheses

1. Does the strength of the relationship between teacher-reported behaviors (anxiety, depression, hyperactivity, aggressivity, conduct) of youth with T1DM differ based on

varying metrics of glucose (average CGM-measures glucose levels during school hours, glucose average during overall week, percent time hyper/hypo-glycemic vs. in-target, and HbA1c)?

a. Hypothesis 1a: Above and beyond socio-demographic (sex, race/ethnicity, BMI, annual household income) and diabetes related variables (insulin delivery method and years since diagnosis), average glucose levels over a week during the school hours will contribute a higher percentage of variance in teacher-reported behaviors than average glucose levels over a full week.
b. Hypothesis 1b: Above and beyond socio-demographic and diabetes related variables, percent time in target range during school hours will contribute a higher percentage of variance in one or more teacher-reported behaviors than glucose average during school.
c. Hypothesis 1c. Above and beyond socio-demographic and diabetes related variables, CGM metrics (average CGM-measures glucose levels during school hours, glucose average during overall week, percent time hyper/hypo-glycemic vs. in-target) will contribute a higher percentage of variance in one or more teacher-reported behaviors than HbA1c.

2. Does physical activity in youth with T1DM predict one or more teacher-reported behaviors (anxiety, depression, hyperactivity, aggressivity, conduct)?
    a. Hypothesis 2a: Above and beyond socio-demographic and diabetes related variables, physical activity (energy expenditure measured by mean kilocalories) will predict one or more teacher-reported behaviors (anxiety, depression, hyperactivity, aggressivity, conduct).

3. Does glycemic control mediate the relations between physical activity and teacher-reported behavior (anxiety, depression, hyperactivity, aggressivity, and conduct)?
    a. Hypothesis 3a. Glycemic control will mediate the relationship between physical activity and one or more teacher-reported behaviors (anxiety, depression, hyperactivity, aggressivity, conduct).

Operational Definitions

Blood glucose (blood sugar) – The amount of glucose in blood. These levels will change depending upon when, how much, and what has been eaten and physical activity.

Blood Sugar Test/Fingerstick – A test that measures the amount of sugar (glucose) in a sample of blood. A finger is pricked with a lancet to obtain a small quantity of blood for testing.

Exercise – Planned, structured, and repetitive activity for the purpose of improving or maintaining physical fitness.

Glucose – The main type of sugar in blood and major source of energy for the body's cells. Glucose comes from the foods we eat, or the body can make it from other substances. Glucose is carried to the cells through the bloodstream. Several hormones, including insulin, control glucose levels in the blood.

Hyperglycemia – An excess of glucose in the bloodstream

Hypoglycemia – A deficiency of glucose in the bloodstream.

Hemoglobin HbA1c (HbA1c) – A blood test that provides an average of blood sugar control over 2-3 months and is reflective of how well diabetes is controlled. The higher the HbA1c level, the poorer the blood sugar control.

Insulin – A hormone needed to allow sugar (glucose) to enter cells to produce energy. In T1DM, the body does not produce insulin.

Insulin Pumps – Device that can continuously deliver insulin to people with diabetes.

Ketones – A chemical produced when there is a shortage of insulin in the blood. Ketones in the urine are a sign that the body is using fat for energy instead of glucose.

Physical Activity – Any movement of the body that requires energy expenditure.

Chapter 2: Literature Review

Type 1 Diabetes Mellitus (T1DM)

T1DM is an autoimmune disease in which the pancreatic beta-cells are destroyed (ADA, 2020). The beta-cell destruction results in a deficiency of insulin and T-cells are liable for the damage. Roughly 80% of an individual's beta cells are likely destroyed over the course of months to years, before diabetes presents in an individual (Cooke & Plotnick, 2008). The destroyed beta cells result in a loss of insulin secretion, which, after time, falls below a critical amount (Daneman, 2006). In many cases, it results in absolute insulin deficiency. In contrast, type 2 diabetes is the result of insulin resistance; the body is able to produce insulin, but the body becomes resistant to it (ADA, 2020).

Although T1DM can appear at any age, it generally presents in childhood or adolescence (ADA, 2020). According to the ADA, approximately 75% of T1DM diagnoses are made in individuals under the age of 18. Worldwide, T1DM is increasing by 3 to 5% yearly **(**Rewers et al., 2008). The ADA reported that 5-10% of diabetes is type 1. At the age of 18, 2 to 3 per 1,000 individuals have a diagnosis of T1DM (Cooke & Plotnick, 2008), and this number is rising.

Due to the chronicity of T1DM, the disease requires daily management, glycemic control, education, nutrition guidance, and psychosocial assistance in order to decrease short- and long-term complications. Support should be provided in the areas of educational, nutritional, behavioral, and emotional factors (ADA, 2020).

Etiology

The cause of T1DM is multifactorial. Cooke and Plotnick (2008) highlighted genetic and environmental factors as cause behind T1DM development. About 10-20% of individuals with T1DM have a family member who is also affected. In those who are genetically vulnerable, environmental factors such as toxins, diet, and viral infections have all been cited as possible contributors to the disease. Specific environmental factors that have been cited include intrauterine and prenatal complications (rubella infection, birth weight), exposure to enteroviruses, a lack of breastfeeding and/or consumption of cows' milk, vitamin D levels, and stress (Long & Bingley, 2009). No preventative measures have been found for T1DM. Furthermore, accepted screening tests are not available to detect individuals who may be at risk (Cooke & Plotnick, 2008; ADA, 2020).

Diagnosis and Criteria for Diagnosis

T1DM is diagnosed via the plasma glucose criteria or AIC criteria (ADA, 2020). The Standards outlined diagnosis criteria. The plasma glucose criteria require the glucose levels that are taken after 8 hours of fasting to be greater than or equal to 126 mg/dL (7.0 mmol/L) or for the 2-hour plasma glucose levels to be greater than or equal to 200 mg/dL (11.1 mmol/L) after a 75-g oral glucose tolerance test. The HbA1c criteria requires HbA1c to be greater than or equal to 6.5% (48 mmol/mol). However, if an individual is experiencing symptoms of hyperglycemia or hypoglycemia, diagnosis criteria require a random plasma glucose level to be greater than or equal to 200 mg/dL (11.1 mmol/L) in order to confirm diagnosis. Nearly one-third of individuals diagnosed are experiencing life-threatening ketoacidosis (ADA, 2020).

Hypoglycemia

Hypoglycemia is characterized by blood glucose levels lower than 60 mg/dL (3.3 mmol/L) and can be caused by missing a meal, exercising too much, or not eating enough for the insulin amount administered. Symptoms can include sweating, trembling, hunger, rapid or irregular heartbeat, headache, lightheadedness, dizziness, double vision, confusion, coma, and seizures. Some bouts of hypoglycemia are treated with consuming glucose, and a source of glucose (food or drink) should be available to treat the symptoms should they arise. If the hypoglycemia is more severe, it is treated with glucagon that is administered into the muscle or under the skin. Glucagon should also be available for severe hypoglycemia (Cooke & Plotnick, 2008).

Hyperglycemia

Hyperglycemia is characterized by high blood glucose levels. This occurs when the body does not have enough insulin. Symptoms of hyperglycemia include increased thirst and frequent urination. If glucose levels are greater than 240 mg/dL (13.9 mmol/L), an individual should check their urine for ketones. When the body lacks the needed insulin to use glucose as energy, the body begins to break down its own fats to use for energy. When this occurs, ketones are generated in the body. The body attempts to purge the ketones through urine. As ketones continue building in the body, diabetic ketoacidosis (DKA) can occur (ADA, 2020). Initial symptoms of diabetic ketoacidosis are extreme thirst, frequent urination, along with high blood glucose levels and ketones in the urine. Other symptoms that can emerge include vomiting, fatigue, difficulty breathing, difficulty paying attention, confusion, dry skin, and a fruity odor on the breath.

DKA is the main cause of illness and death in youth with T1DM (Dunger et al., 2004). It is estimated that DKA is existent in 15-67% of youth at diagnosis. At diagnosis, DKA is more frequently seen in children under age 4, those without a 1st degree family member with T1DM, and individuals with lower SES (Dunger et al., 2004). In individuals with established cases of T1DM, the likelihood of DKA is 1-10% yearly. Deaths from DKA are estimated at 0.15% in the United States (Dunger et al., 2004). A protective factor against DKA involves youth who are administered insulin by an adult, as they have less of a chance to experience insulin exclusion or error. Risk factors for experiencing DKA include poor metabolic control, adolescent females around the time of puberty, having a psychiatric disorder, and individuals with familial problems such as lower SES and lack of health insurance.

HbA1c Levels

The HbA1c blood test is a measurement of glycemia over a 3-month period. The HbA1c test uses red blood cells or erythrocytes, which live for approximately 120 days. This is a "weighted" measurement, as the levels in the last 30-days contribute more to the results than the last 90-120 days. HbA1c tests determine average glucose levels and clinicians can use that information to estimate daily glucose goals (NGSP, 2010). In a landmark Diabetes Control and Complications Trial (DCCT), HbA1c levels showed a linear relationship with daily average glucose levels and were predictive of diabetic complications (ADA, 2020). Recommendations from the ADA suggest that HbA1c levels should be below 7.5% in youth. However, the goals set should be made on an individualized basis. In conjunction to monitoring HbA1c levels quarterly, the use of basal-boluses, insulin pumps, the regularity at which blood-glucose levels are checked, the use of goals, and ongoing education have all increased adherence to recommended blood-glucose levels (ADA, 2020).

Based on a study by Paris et al. (2009), in youth less than 20 years old with T1DM, it was found that insulin pump therapy was connected with lower HbA1c levels. The authors, consistent with previous literature, found that age was connected with a greater average HbA1c level and lowered the success of meeting their HbA1c goals, unrelated to the insulin routine. Specifically, adolescents were found to have high HbA1c levels (Paris et al., 2009).

Although HbA1c is an exceptional measurement in the management of T1DM, it does come with some limitations. While HbA1c is correlated to average glucose levels, it is unable to illustrate the daily fluctuations and variability in glycemic control. Due to this, the Standards note the importance of continuous glucose monitoring for the ideal management. With momentary glycemic control, it could be possible to better understand the correspondence between glucose levels and how a student is behaving in school.

Continuous Glucose Monitor

Coupled with checking HbA1c levels, the use of self-monitoring blood glucose levels through a CGM has become an advantageous form of glycemic management. The ADA (2020) highlight that a CGM can assist in treatment, medication, nutrition, and physical activity decisions as well as reducing the risk of hypoglycemia. ADA recommends that CGM's are considered for all youth with T1DM. CGM devices provide blinded or unblinded results in varying designs.

Table 1

CGM Devices

CGM Device	Description
Real-time CGM	CGM systems that measure glucose levels continuously and provide the user with automated alarms and alerts at specific glucose levels and/or for changing glucose levels.
Intermittently scanned CGM	CGM systems that measure glucose levels continuously but only display glucose values when swiped by a reader or a smartphone that reveals the glucose levels.
Blinded (professional) CGM	CGM devices that measure glucose levels that are not displayed to the patient in real time. These devices are generally initiated in a clinic, using a reader that is owned by the clinic. They are removed after a period of time (generally 10–14 days) and analyzed by the patient and provider to assess glycemic patterns and trends.
Unblinded CGM	CGM devices that measure glucose levels that are displayed to the patient.

In trials that have studied the CGM's impact on glycemic control, specifically in youth, the results are varied. One research study sought to assess the benefits of CGM's in participants aged 4-9 years old. Participants wore an unblinded CGM device for 26 weeks and agreed to perform at least 4 blood glucose readings per day. Participants were visited during weeks 1, 4, 8, 13, 19, and 26. The visits consisted of reviewing CGM data, making any adjustments in medication that were needed, and obtaining HbA1c. Final glycemic control was assessed after a 26-week follow up. Over the 26-weeks, CGM sensor wear decreased. The findings did not show that the CGM statistically improved glycemic control. However, the participants who continued to wear the CGM for 6 or more days per week showed more of a decrease in HbA1c than those who wore the sensor less. The CGM can be a useful tool in lowering HbA1c levels but is dependent on the frequency of use and adherence to the device (Mauras et al., 2012). In other studies, with participants including both children and adults with T1DM, the results have been more promising. Battelino et al. (2012) found that CGM use correlated to lower HbA1c levels. Deiss et al. (2006) found similar results in their randomized control trial of adults and children. Their research, spanning a three-month period, showed a 1% decrease in HbA1c in half of their participants who used a real-time CGM. A quarter of the participants using the real-time CGM decreased their HbA1c by 2%. The mixed results among studies indicate that the frequency in which participants adjust in their insulin and the appropriate use of the CGM's are imperative in the device's effectiveness.

Sociocultural Factors

Several studies have found that socioeconomic status is correlated to glycemic control, with lower socioeconomic status lending itself to poorer glycemic control (Gallegos-Macias et al., 2003; Hassan et al., 2006; Secrest et al., 2011; Petitti et al., 2009). Low sociocultural status also has been associated with a higher likelihood of psychiatric issues, increased physical disability, more mental health issues, and worse access to healthcare (Lorant, et al., 2003; Brenes et al., 2008). An unproportionate level of minorities are receiving lower-end health care (Nelson, 2002). When examining glycemic control between Hispanic and white non-Hispanic participants, Gallegos-Macias et al. (2003) found that Hispanic youth had HbA1c levels that were significantly higher than the white non-Hispanic group. The most striking differences between the groups showed that Hispanic families had significantly lower income, lower parental education, and higher state-supported insurance. The groups did not show a significant difference in duration of diabetes, age of onset, or BMI. Across groups, income showed statistical significance when compared to HbA1c levels (Gallegos-Macias et al., 2003).

T1DM and Physical Activity

Physical activity is defined as bodily movement that increases energy expenditure. A form of physical activity is exercise, which is intended to improve health and fitness. It is recommended that all children engage in a minimum of 60 minutes of physical activity daily. These 60 minutes can be reached cumulatively throughout the day (Strong et al., 2005). The ADA (2020) echoes the general research on physical activity in T1DM, urging 60 minutes of daily vigorous intensity, including muscle and bone strengthening activities. The ADA noted that regular physical activity is an important aspect to the management of T1DM that exercise can decrease cardiovascular risks, strengthen muscles, and improve insulin sensitivity. Reducing sedentary time is also encouraged. Reducing activities such as television, computer, telephone, and video game use to under two hours per day is urged (Strong et al., 2005).

According to Strong et al. (2005), physical activity changes with age. For example, crawling and walking accounts for physical activity in infancy. Preschool-aged children learn basic movements and, as they mature, they become more coordinated, and movements become more complex. Guided instruction and childhood games continue to assist in the learning of basic to specialized motor skills. Around ages 10-14, youth engage more in individual and group activities, such as organized sports, with more structured physical activities emerging in 15-18-years-old.

Physical activity can be classified into three categories: low, moderate, and vigorous. This is based on metabolic equivalents of certain activities related to the ratio of activity to resting energy expenditure (Strong et al., 2005). The authors explain that moderate-to-vigorous physical activity can include activities such as brisk walking, bicycling, and outdoor playing.

Janssen and LeBlanc (2010) completed a review of physical activity health benefits in youth. In observational studies, results showed that the more physical activity youth engaged in, the greater the health benefits. In experimental studies, it was shown that meaningful health benefits were achieved through moderately intense physical activity, with vigorous activity offering more benefits. Their findings on the recommendations of physical activity echoed the suggestions made by the ADA that youth should engage in 60 minutes of physical activity per day. However, in those youth who were high-risk, engaging in even 30 minutes of moderately intense activities provided health benefits. Furthermore, the authors found that youth should engage in aerobic activities primarily, with strengthening activities incorporated 3 times per week.

Although exercise is important, an individual with T1DM must take precautions to prepare for physical activity. The ADA stresses that individuals with T1DM should be able to participate in physical activity but suggest extra care be given to footwear and care of the feet, hydration before, during, and after the activity, and displaying a diabetes identification tag (ADA, 2020). According to Leclair et al. (2013), hypoglycemia and glycemic control can prove to be a challenge for physically active youth with TIDM. Because hypoglycemia can be a risk of physical activity, blood glucose levels should be monitored closely. Individuals should adjust their medication dose and/or carbohydrate intake (ADA, 2020). At school, students may need to adjust their insulin and food amounts to account for participation in physical education classes or sporting events. It is important to have food available in order to increase carbohydrates, if necessary (Jackson et al., 2015).

A study examining physical activity and fitness in youth aged 8-16 with T1DM as compared to controls (Cuenca-García et al., 2012) indicated the important role physical activity had in glycemic control. Participants wore actigraphs and cut points were decided to determine minutes spent engaging in light and moderate to vigorous physical activity per day. The actigraph measured accelerations in activity, which was used as the measure of physical activity. The results showed that moderate to vigorous physical activity was related to better glycemic control and lower HbA1c, suggesting that the intensity of physical activity has an effect on long-term glycemic control. Both the time spent engaging in physical activity and the intensity improved glycemic control. Surprisingly, the authors found that the participants were only participating in physical activity (moderate to vigorous) for 42 minutes daily, versus the recommended 60 minutes daily. Michaliszyn and Faulkner (2010) found similar results in 16 adolescents diagnosed with T1DM between ages 12-17 participated in the study. Participants wore an actigraph for 16 weeks in order to measure their physical activity. The authors reported decreased levels of HbA1c by engaging in moderate to vigorous physical activity.

Beraki et al. (2014) compared HbA1c levels to levels of physical activity in 4655 individuals ages 7-18 with T1DM. The authors used a database connected to a diabetes clinic that collected data such as HbA1c, hypoglycemic episodes, physical activity, etc. The authors divided physical activity that lasted at least 30 minutes into the following categories: none, less than once per week, 1-2 times per week, 3-5 times per week, and every day. The authors found a statistically significant reverse association between physical activity and HbA1c levels, indicating that engaging in physical activity was related to improved metabolic control. However, the authors noted that the participants with higher self-reported levels of physical activity had increased hypoglycemia, calling attention to the importance of educating individuals about food intake and insulin dosage during physical activity.

Internalizing and Externalizing Behaviors in T1DM

Over the past few years, the Standards have increasingly emphasized the interplay of physical and mental health. In particular, the Standards recommend that psychosocial factors be addressed as a part of the care of individuals with diabetes; this includes conducting an initial evaluation, reevaluating outcomes periodically, participating in collaborative care, providing resources, and monitoring of patients' regime. This not only identifies symptoms but also addresses them and outlines a continuation of care in monitoring these symptoms. Since psychological health can impact an individual's potential for caring for their diabetes, screening and potential follow-up assessment is recommended for a variety of psychosocial issues, including anxiety and depression.

The ADA (2020) outlined Diabetes Self-Management Education and Support (DSMES) to ensure that patients are receiving the necessary services for the most optimal support in caring for their diabetes. The literature has featured systematic efforts to implement routine screening to identify mental health symptoms in individuals with T1DM (Perfect et al., 2011; ADA, 2020), including data to support the feasibility, the process, and the associated outcomes (Perfect et al., 2011). Nonetheless, students can be particularly vulnerable due to comorbidities and the numerous transitions experienced at a young age, which places them at jeopardy for gaps in follow-up care due missed appointments (Ducat et al., 2014). The Standards note that, among other factors, school schedules and conditions, status of health behaviors (e.g., physical activity), and comorbidities should be integrated into the patient's care plan. The inclusion of psychosocial care in the Standards is encouraging, as it shows dedication to not just identifying symptoms, but connecting patients with services that can lead to improvements. One meta-analysis showed that psychosocial interventions significantly improved HbA1c levels as well as mental health (Harkness et al., 2010). There was a narrow association between HbA1c and mental health. But overall, research has shown that combining treatment for mental and physical health improves results (ADA, 2020).

Although school is identified as a part of a patient's diabetes management plan, there are very little data about how symptoms manifest in school and even more limited, is the perspective of teachers in the understanding of patient symptoms and care. Teachers could serve as useful informants on a variety of symptoms and behaviors such as depression, anxiety, attentional problems, hyperactivity, and aggression.

Internalizing Symptoms

Internalizing problems are disordered feelings and moods directed inward. They are also referred to as "emotional disorders." Internalizing disorders are often associated with depression, anxiety, and anhedonia (Lau et al., 2019).

Previous research has shown associations between T1DM and internalizing problems. Akbaş et al. (2009) sought to further investigate the association between T1DM and internalizing problems as well as the association between psychiatric problems and metabolic control in T1DM. A parent of each child with T1DM completed the Child Behavior Checklist (CBCL). The results of the CBCL showed that, when compared to the control group, individuals with T1DM were rated by their parent as having increased problem scores in the social competence, total competence, withdrawal, anxiety/depression, social problems, and aggressive behavior composites. Although the social composites and emotional and behavior composites were elevated in the group with T1DM, these participants did not show that they received more psychiatric support compared to the control group.

A similar study conducted in China sought to find any problems in behavior in youth with T1DM (Zheng & Chen, 2013) using the CBCL. The study included 45 individuals with T1DM and 53 control individuals. The control group consisted of children aged 6-15 years old who were considered healthy, whereas the experimental group was children 6-15 years old with a diagnosis of T1DM. Parents completed the CBCL. Similar to previously reported studies, the experimental group had significantly higher withdrawal, anxiety/depression, attention problems, delinquent behavior, aggressive behavior, externalizing problems, and internalizing problems.

Anxiety

Anxiety Identification. Anxiety is described as an emotion paired with discomfort, apprehension, and is usually tied with an autonomic response. Experiencing some levels of anxiety is normal, however, it can become severe and impair childhood involvement with peers, in school, or with attainment of some developmental tasks (Albano et al., 2003). There are multiple types of anxiety disorders, including panic disorder, social anxiety disorder, specific phobias, and generalized anxiety disorder, and separation anxiety disorder. With anxiety as the main symptom in each of the anxiety disorders, they can each be expressed through varying cognitive, physiological, and behavioral reactions (Albano et al., 2003). When determining a diagnosis, practitioners will consider the length of time that symptoms have been present, what the symptoms are, and how it may interfere with routines. Anxiety can also be separated into state or trait anxiety. In general, state anxiety is temporary and occurs in response to a more situational occurrence while trait anxiety is more chronic.

Anxiety Prevalence. In the general population, anxiety diagnoses in youth range from 10-20% (Kendall et al., 2010). As aforementioned, youth with T1DM are at a greater risk of mental health conditions, including anxiety, which occur in 33-42% of individuals with T1DM (Rechenberg et al., 2017). Specifically, anxiety symptoms rates for youth with T1DM are noted to occur at 13-21.3% while an anxiety diagnosis was found to occur in 18.4% of youth with T1DM (Rechenberg et al., 2017).

Anxiety measures. The degree to which anxious symptoms are present and the interference in academic, social, or occupational regimes, can be gathered through structured interviews, rating scales, and self-report assessments (Albano et al., 2003). Instruments such as the State-Trait Anxiety Inventory and The Screen for Child Anxiety Related Disorders (SCARED) are widely used anxiety measures to assist with youth diagnosis of anxiety.

Anxiety Symptoms in T1DM. It is important to understand the impact anxiety can have on youth's care for their diabetes. For example, research has shown that anxiety can not only affect the quality of life but also glycemic control (Rechenberg et al., 2017). In a review of 15 studies, Rechenberg et al. (2017) found that 75% of the studies found a correlation between anxiety and poorer health in youth with T1DM. Health outcomes were measured through glycemic control, fear of hypoglycemic, worry about hypoglycemia, family conflict, depressive symptoms, blood glucose monitoring, and quality of life. Anxiety has shown a negative impact on glycemic control (Buchberger et al., 2016).

Gonder-Frederick et al. (2002) focused on the literature on anxiety and the authors noted that fewer studies had been completed in this area. However, it was shown that anxiety affects the body's sympathetic nervous system, which activates the fight-or-flight response, and patients with diabetes may view these symptoms as relating to their diabetes, rather than anxiety. In turn, this could lead to an unnecessary self-treatment of hyperglycemia. More research is being conducted on how prolonged hypo- and hyperglycemic can affect individuals psychologically.

Anxiety and Physical Activity. There are many known benefits in engaging in physical activity, including the positive outcomes it can have on mental health. In one metanalysis that Paluska and Schwenk (2000) reviewed physical activity as a treatment for depression and anxiety in adults. The authors found that exercise was linked to lower symptoms of anxiety. An interesting finding was that the length of the engagement in physical activity mattered for a reduction in anxiety. For example, individuals had to engaged in exercise for at least 21 minutes per session for a minimum of 10 weeks was needed to show a reduction in trait anxiety. The benefits leveled off after 40 minutes of exercise per session.

Another study Paluska and Schwenk (2002) included in their metaanalysis assigned participants to one of three groups: a seven-week aerobic exercise group, a seven-week anxiety management plan, and a control group. The exercise group participated in 1 hour of exercise 3 times per week while the anxiety management plan group participated in their sessions twice per week for 1 hour. Both experimental groups showed a decrease in state anxiety, and those in the exercise group also showed a decrease in trait anxiety (Lobitz et al., 1983).

Anxiety and Physical Activity in T1DM. The ADA has noted the importance of physical activity and exercise in individuals with diabetes. Not only can it improve glucose management and improve some health factors, it can also improve well-being (ADA, 2020). Åman et al. (2009) found an association between physical activity and mental health in youth with T1DM, including increased well-being, decreased worry, and better quality of life. In their research, participants (ages 11-18) completed self-report surveys (Diabetes Quality of Life – Short Form and Health Behavior in School-aged Children questionnaire) and reported their physical activity levels within the last week. Although the association between physical activity and the broader umbrella of mental health is of critical importance, understanding the specific areas of mental health that can be improved is also significant.

Mutlu et al. (2015) examined the effect of physical activity on health-related quality of life (HRQoL) in participants with T1DM and looked more specifically at anxiety-related outcomes. Physical activity was measured using a self-reported measure: The PA Questionnaire for Older Children (PAQ-C). The health-related measures were assessed with the Children's Depression Inventory (CDI), the Screen for Anxiety Related Emotional Disorders (SCARED), and the Pediatric Quality of Life Inventory self-report form for children aged 8-12 (PedsQL 4.0) which was used to assess HrQoL. The analysis found that the participants with T1DM had significantly higher depression and anxiety scores and lower quality of life scores when compared to the control group. Physical activity was found to be associated with the HRQoL-Child form but not with depression or anxiety. The authors proposed that due to the chronic nature of T1DM, physical activity may not be able to lower levels of depression and anxiety. In addition, the use of the self-report physical activity questionnaire, while being advantageous in many ways, may not have fully assessed the breadth and depth of the physical activity that the participants engaged in. And finally, the participants, aged 8-12, were all Caucasian, which could limit the generalizability of the findings.

Depression

Depression Identification. Depression can include feelings of sadness and losing interest in activities. These symptoms can impact the way in which individuals think and feel, leading to impairment in social, vocational, or other areas of performance, such as interpersonal functioning (American Psychiatric Association [APA], 2013; Ani et al., 2008).

Depression Prevalence. In the general population, depression affects 6.7% of adults in the US (Ducat et al., 2014). In individuals with diabetes (type 1 and 2), depression is twice as likely than that of the general population. In youth with T1DM, depression rates are higher than that of youth without T1DM (Ducat et al., 2014), occurring at 11.3-27.5% (Rechenberg, et al., 2017). Specifically, in youth, the rate of major depressive disorders is 5.3%, whereas in youth with T1DM, the rates were at 8.3% (Gendelman et al., 2009). A metanalysis by Buchberger et al. (2016) examined 14 studies that focused on depression and anxiety in youth with T1DM. The prevalence of depressive symptoms was found to be 30.04%. (Gendelman et al., 2009; Rechenberg et al., 2017). Linked with depression is the decline in treatment adherence (management and glycemic control) and health outcomes, physical and mental (Ducat et al., 2014; Buchberger et al., 2016).

Depression Measures. Measurement tools are a vital part of identifying and monitoring symptoms of depression (Trivedi, 2009). Rating scales are a useful and sensitive tool that can be used in patient care and ensure a baseline for clinician and patient decision-making (Trivedi, 2009). Examples of assessments that specifically examine the domains of depression are: Patient Health Questionnaire, Quick Inventory of Depressive Symptomatology, and the Beck Depression Inventory. Clinical interviews can also be useful as a measurement tool for depressive symptoms. Interviews can obtain the patient’s history, any relevant diagnoses, and demographic information (Cavanaugh et al., 2001). Specific to individuals with T1DM, the Problem Areas in Diabetes (PAID) assessment can be used to examine distress in individuals who have been diagnosed with T1DM.

Depressive Symptoms in T1DM. The ADA (2020) suggests that by age 7-8, youth with T1DM should begin receiving screenings for depression, anxiety, and disordered eating. In addition, the Standards indicate that clinicians should address the topics of social adjustment and school performance with youth, again highlighting the importance of including school personnel in the wrap-around services that should be provided for youth with T1DM. Gonder-Frederick et al. (2002) cited the importance of psychopathology in a youth's diabetes management. The authors noted that depression occurs in 15-20% of youth with T1DM. They explained that depression could affect their diligence in self-management of their disease. Of course, there is uncertainty if depressive symptoms can lead to decreased self-treatment or if decreased self-treatment can lead to depressive symptoms.

Various studies have investigated diabetes and depression and have shown an improvement in both when depression is treated (Katon et al., 2004). In patients with diabetes, depression has been linked to a poorer diet, less exercise, and decreases in checking blood glucose level. It is also linked to a higher HbA1c. As noted in the Standards, research by Katon et al. (2004), provided a randomized trial with one group receiving standard care that had been provided and a Pathways case management intervention. The group receiving standard care was referred to their primary care doctor for their depressive symptoms and could receive antidepressant medication if the primary care doctor saw that as a viable option. The intervention group received treatment from a clinical specialist nurse with collaboration from the primary care doctor. The treatment was a "stepped-care approach," beginning with a choice between starting antidepressant medication or receiving the Pathways intervention. The initial Pathways appointment consisted of a 1-hour session and following appointments of 30 minutes every other week for up to 12 weeks. The participant's response to the treatment was reassessed at 10-12 weeks and treatment was either increased or began gradually tapering. Data was collected at baseline, 3-months, 6-months, and 12-months. The authors found that the Pathways model used was effective in improving depression outcomes. However, the depression care did not improve glycemic control. The mean HbA1c levels of participants in this study was 8.0%, which could have been a limiting factor in the reduction of HbA1c, as the initial levels were already fairly low. The authors suggested that integrating depression care with diabetes management could be a useful direction for improving both depressive symptoms and HbA1c.

Depression and Physical Activity. In regard to physical activity, the research has shown an association between higher levels of physical activity and exercise with increased mental health. Likewise, evidence has suggested that exercise can reduce depressive symptoms. Overall, exercise is shown to improve mood and well-being (Ströhle, 2009). The exact reasons behind the improvement are not known but a number of mechanisms have been suggested. For example, psychological factors may play a role in the improvement, with the author noting research has pointed to self-efficacy, sense of mastery, distraction, and changes of self-concept. Biological changes in the body have also been theorized. Examples of this include increased central norepinephrine neurotransmission, hypothalamic adrenocortical changes, increased secretion of a feedback mechanism that helps regulate blood pressure, amine metabolites, intrinsic serotonin production and breakdown, and beta endorphins, which are utilized in the body to maintain homeostasis and reduce stress (Ströhle, 2009).

Ströhle (2009) conducted a meta-analysis examining the correlation of physical activity and exercise with depression and anxiety as well as therapeutic benefits of exercise. The author highlights that depression rates are lower in individuals who engage in physical activity. Studies have also shown that physical activity and exercise have been used as an effective treatment for depression and anxiety. However, a developed therapeutic system for the treatment of depression with the use of physical activity and exercise has not been shown in the research (Ströhle, 2009).

Lloyd et al. (2010) examined depressive symptoms and diabetes self-care in individuals with T1DM who had received their T1DM diagnosis prior to the age of 17. The authors included four self-reported physical activity measures, including total estimated energy expenditure in the past week and on average per week during the past year, and energy expenditure from sporting activities in the past week, and per week in the past year. Energy expenditure was a self-reported estimate of the number of flights of stairs taken, city blocks walked, and time spent engaged in a sporting activity. Of those, all four physical activity metrics showed a significant negative correlation to depressive symptoms as measured by the Beck Depression Inventory (BDI) and Center for Epidemiological Studies of Depression Scale (CES-D). Although studies have examined depression and diabetes, very few have investigated the role physical activity plays with depression in T1DM.

Externalizing Symptoms

Externalizing behaviors are negative or maladaptive behaviors expelled into the physical environment demonstrated in hyperactivity, noncompliance, aggression, etc. (Donenberg & Baker, 1993). In childhood, externalizing behaviors are associated with disorders such as attention-deficit hyperactivity disorder, oppositional defiant disorder, and conduct disorder (Hatoum et al., 2018). McDonnell et al. (2007) found that higher mean blood glucose levels, more time spent in the hyperglycemic range, and less time spent in the target range were correlated to increased externalizing behaviors. Mean blood glucose levels were measured through a CGM and calculated as a percentage of time spent in low, normal, and high glucose level ranges. Specifically, higher mean blood glucose levels and time spent in the hyperglycemic range were associated with more externalizing problems while more time spent in the target range was associated with fewer externalizing problems. No association was found when the authors looked at time spent in hypoglycemia and externalizing behaviors. Additionally, variation in the mean blood glucose levels did not show an association with externalizing behaviors.

Hyperactivity

Hyperactivity Identification. Hyperactivity is a behavior characterized by constant fidgeting, excessive physical movement, difficulty waiting turns, etc. It is most commonly ascribed to a disorder referred to as Attention Deficit Hyperactivity Disorder (ADHD). ADHD is characterized by both hyperactivity/impulsivity and attentional deficits. ADHD is characterized by attentional deficits and hyperactivity/impulsivity and attentional deficits. There are a set of criteria that an individual must meet to be diagnosed with ADHD. The DSM-V outlines two components in which criteria for ADHD can be met: inattention and/or hyperactivity/impulsivity. The symptoms must occur in more than one setting and influence the individual's functioning. Individuals with ADHD have trouble with planning and organization. Taken together, these symptoms can negatively impact diabetes management (Yazar et al., 2019).

Hyperactivity Prevalence. The prevalence of hyperactivity by itself has not been reported. However, ADHD has an estimated prevalence of 3-11% in school-aged students (de Zeeuw et al., 2017; Quesada et al., 2018), which is an estimated 6.4 million children in the United States (Quesada et al., 2018). Worldwide, 26 million individuals have ADHD diagnoses (Parker et al., 2016). Those numbers make ADHD the most common disorder of childhood (Yazar et al., 2019). ADHD is highly hereditary, with estimates of heritability of up to 70% (de

Zeeuw et al., 2017). There is a male to female ratio of 3:1 (Parker et at., 2016). It has been hypothesized that there may be an under identification of females though (Parker et al., 2016).

Hyperactivity Measures. Observation and questionnaires are frequently used as a means of identifying hyperactivity symptoms. When identifying symptoms of hyperactivity, a youth's behavior should be observable by multiple raters and across multiple settings (Collett, Ohan, & Myers, 2003). Some broader behavioral assessments that include hyperactivity as a composite are the Behavior Assessment System for Children and the Child Behavior Checklist. More narrow band assessments for hyperactivity include The Conner's Rating Scales and the Vanderbilt ADHD Rating Scales, which both of which identify hyperactivity symptoms in children (Collett et al., 2003).

Hyperactivity Symptoms in T1DM. Symptoms of hyperactivity in individuals with T1DM can have negative outcomes on their diabetes management (Hilgard et al., 2016). Some studies have shown that this population can have increased occurrence of DKA and severe hypoglycemia (Hilgard et al., 2016). A 2019 study looked specifically at individuals aged 5-18 years old with diagnoses of T1DM and ADHD and a control group with diagnoses of only T1DM. The individuals with ADHD had significantly higher HbA1c levels compared to the control group. The control group showed mean HbA1c levels of 8.17%, while those with the dual diagnosis had a mean HbA1c of 9.9% (Vinker-Shuster et al., 2019). Likewise, Nylander et al. (2017) also found an association between ADHD and higher HbA1c levels. Yazar et al. (2019) found similar results with ADHD diagnoses having a negative effect on diabetes management in youth with T1DM. The symptoms of ADHD, including hyperactivity and poor executive functioning, may interfere with a child's glycemic control (Yazer et al., 2019). The authors also noted that research is limited surrounding the effect ADHD has on T1DM management (Vinker-Shuster et al., 2019).

Hyperactivity and Physical Activity. Cross sectionally, exercise interventions and sports involvement have been shown to lessen the symptoms of hyperactivity (Peralta et al., 2018). After physical activity interventions involving moderate to intense exercise, both parents and teachers have reported improvements in their child's/student's behavior, processing, motor skills, and muscular capacity (Parker et al., 2016). However, when studied longitudinally by Peralta et al. (2018), the authors did not find that exercise was associated with improved symptoms of hyperactivity. Although there is some evidence to suggest that engaging in physical activity has some positive results in individuals with hyperactivity, more research is needed. Parker et al. (2016) described that there is variation in duration, intensity, and type of exercise in the studies conducted.

Hyperactivity and Physical Activity in T1DM. Although there is research on hyperactivity, physical activity, and youth with T1DM in various permutations, the research combining those three topics was absent in the literature.

Aggressivity and Conduct Problems

Aggressivity and Conduct Problems Identification. Anger is characterized by negative affect, psychological arousal, thoughts of blame, and possible increased aggressive behavior (Sukhodolsky et al., 2016). In general, anger is a normal emotion that individuals experience. It can be felt inwardly or expressed outwardly (Sukhodolsky et al., 2016) and can vary in expression and length. Aggression on the other hand is a behavior that involves causing physical, psychological, or relational harm (Wade et al., 2018). Anger, aggression, and irritability are some of the main reasons for mental health referrals (Sukhodolsky et al., 2016). Aggression may occur without diagnosis or disorder. When attempting to identify behavioral symptoms of aggression and match it with a potential diagnosis, according to the DSM-5, anger and defiance in childhood is linked with oppositional defiant disorder (ODD) and aggression is linked with conduct disorder (APA, 2013). Conduct disorder can reflect a set of antisocial behaviors such as rule breaking and acting out toward others (fighting, lying, stealing, etc.) (Kazdin, 1997). As with other disorders, some infrequent and mild behaviors stated above can be seen as typical, but when it becomes significant and severe, based on frequency, intensity, and the duration of time the behaviors have occurred, is when it may be considered a conduct disorder. In addition, these behaviors must impair the child's life according to important adults in the child's life (Kazdin, 1997).

Aggressivity and Conduct Problems Prevalence. Disruptive behavioral disorders are cited at occurring between 14 and 35% in children with ADHD, 14-26% in those with anxiety diagnoses, and 9-45% in those with mood disorders (Sukhodolsky et al., 2016). In regard to aggressivity, males are more likely to display physical and verbal aggression whereas females were more likely to engage in indirect aggression (Sharma & Marimuthu, 2014). Sharma and Marimuthu examined the prevalence of aggression in youth and found that 17.70% of youth had elevated mean scores on aggression measures (2014). The prevalence of diagnosed conduct disorders in the United States has been shown to be about 9.5% of the population. The overall prevalence of conduct disorder in females was estimated at 7.1% in the United States. The prevalence of conduct disorder in males was estimated at 12.0% in the United States. Using data from the National Comorbidity Survey Replication, the median age of onset for conduct disorder was estimated at 11.6 years of age (Nock et al., 2006). The prevalence is correlated with lower education, marital disruption of parents, and living in urban communities (Nock et al., 2006).

Interestingly, the prevalence is higher in the Western United States (research is unclear as to why). In addition, the prevalence is lower for individuals who identify as Hispanic (Nock et al., 2006). Conduct problems, not necessarily a diagnosed conduct disorder, can put individuals at increased risk for substance use, violence, depression, and suicide (Yu et al., 2006).

Aggressivity and Conduct Problems Measures. Aggression can be identified through various measures. Observation and questionnaires can be used to get a measurement of aggression in youth. For example, some self-report measures ask questions about how often youth engaged in a certain activity, such as pushing another student, in the past week (Orpinas & Frankowski, 2001; Northam et al., 2005). The CBCL questionnaire is another useful tool (Northam et al., 2005). The CBCL and Behavior Assessment System for Children, Second Edition (BASC-2) ask questions surrounding aggressivity, oppositional defiant problems, and conduct problems (McDonnell et al., 2007; Northam et al., 2005). Structured diagnostic interviews are also useful assessments. The National Comorbidity Survey Replication (NCS-R) is a survey more specific to conduct disorder that aligns with DSM-IV and ICD-10 criteria for diagnosis of conduct disorder (Nock et al., 2006).

Aggressivity and Conduct Problems Symptoms in T1DM. Maladjustment has been associated with poorer treatment adherence which, in turn, leads to poorer metabolic control (Northam et al., 2005). McDonnell et al. (2007) found that the more time children were in a high glycemic range, the higher their externalizing problems score was on the BASC-2, parent rating scale. Conduct disorder was a part of the externalizing scale. This study used a CGM rather than HbA1c.

Leonard et al. (2002) studied glycosylated hemoglobin and behavior problems in 234 youth with T1DM, aged 11-18, using the Youth Self Report (YSR). The YSR included the following scales: withdrawal, somatic complaints, anxious/depressed, social problems, thought problems, attention problems, delinquent behavior, and aggressive behavior. Glycosylated hemoglobin was taken during a routine clinic visit and the YSR was either filled out at the clinic or was sent home with the participant, along with a stamped envelope. Participants who were identified as having increased levels of aggressivity and delinquent behaviors had increased levels of glycosylated hemoglobin. In fact, those individuals were twice as likely to have glycosylated hemoglobin above 9%. It is important to remember the more immediate reactions of an individual when diabetes is poorly controlled. As the body reacts to the physical effects of uncontrolled glycemic levels, an individual can experience negative mood and irritable/aggressive behavior, among others. (Vanstone et al., 2015)

Aggressivity, Conduct Problems, and Physical Activity. Wade et al. (2018) reiterated the body of literature that notes the beneficial effects of physical activity on mental health. The authors noted that most research has been conducted to examine the link between physical activity and internalizing problems but a small yet encouraging body of literature has examined physical activity and externalizing behaviors. One hypothesis as to why physical activity would have positive effects on aggressive behavior may be the fact that while engaging in physical activity, youth are not engaging in other activities that have been linked with aggressivity, such as spending time on technology (Wade et al., 2018). Another hypothesis is that youth who participate in more physical activity can have improved self-perception, which could lead to less aggression (Wade et al., 2018).

Wade et al. (2018) examined the effects of a school-based physical activity intervention on aggression in adolescent males. A total of 361 participants were randomly assigned to the intervention group or the control group. The intervention group received three 20-minute seminars, twenty 90-minute "sport" sessions that were mainly centered around resistance exercises and incorporated "rough and tumble play," six 20-minute mentoring sessions, and use of pedometers. The participants used an app or website for goal setting. Newsletters were sent to each participant's parent in regard to decreasing screen use. Questionnaires on aggression, screen time usage, and perceived strength were given at baseline and after the study concluded, at 8-months. The pedometer, or accelerometer, was used to gather physical activity data. There was a greater reduction in reported aggressivity in the intervention group, but it was not statistically significant.

In a study conducted in China, the authors examined the association between academics, self-esteem, conduct, and physical activity in children ages 8-12. Physical activity was measured using the Physical activity questionnaire for children (PAQ-C). Conduct "grades" were retrieved from the student's report cards completed by their teachers. Results showed that in the male students, the more physically active they were, the better their conduct score was. In the female students, the more physically active they were, the worse their conduct grades were (Yu et al., 2006). The authors hypothesized that the expectation of gender norms may be challenged when girls are more physically active, which could have shown the negative perception. However, in boys, the authors suggested that improved self-esteem, increased feelings of achievement, and sportsmanship toward others. Another study by Calfas and Taylor (1994) examined physical activity in adolescents (aged 11-21) in relation to a number of psychological conditions. When looking at physical activity relative to hostility/anger the data were inconclusive.

Aggressivity, Conduct Problems, and Physical Activity in T1DM. The literature on T1DM as it pertains to aggressivity, conduct behaviors, and physical activity was scant. This is a gap in the literature where more research can be conducted.

School Functioning in Students with T1DM

Students spend 7-10 hours at school per weekday. During the school day, students with T1DM should perform fingersticks to measure their glucose, inject insulin, and adjust the dose when needed (Izquierdo et al., 2009). Diabetes care at school is crucial and plays an important role in their safety, long-term outcomes, and their academic performance (Jackson et al., 2015). Since the DCCT showed a link between glycemic control and complications of diabetes, it is important for students to manage their diabetes while at school. Due to the need for diabetes management at school, students are faced with a multitude of challenges, such as, having limited access to check and treat their glucose levels, facing restriction of extracurriculars, feeling as though they are stigmatized, and being treated differently. Those factors can then lead to more absences, depressed mood, increased stress, poorer academic performance, and diminished quality of life (Pansier & Schulz, 2015).

In a study examining the perceptions of children diagnosed with T1DM, their teachers, and their parents, it was reported that 25% of parents thought their child hid their diabetes at school. Eighty-four percent of parents felt their child could control their diabetes independently. Alarmingly, the authors found that only 61-65% of the children reported checking their glucose in school and 25% did not even disclose to the school that they had diabetes (Amillategui et al., 2009).

Research with participants in Italy examined parent and teacher impressions on youths' experiences in school (Pinelli et al., 2011). Results showed that 46.8% of parents reported that their child did not take insulin while at school. In the students who did administer insulin at school, parents reported that 25.5% administered insulin themselves, 20% received insulin assistance through a parent or relative, 3.6% used the nurse for assistance, and 2.7% had help from a teacher with administration. Teachers were surveyed about training opportunities and 40.4% had received some training in T1DM, with 61.9% receiving it from parents and 33.3% from the Diabetic Unit. Roughly half of the teachers surveyed described some special procedures being taken for students with T1DM during extracurriculars and 23% expressed that their school would be fully prepared in the event of an emergency. However, more training and increased information was desired by the teachers.

Since schools play such a large role in students' lives, the complexity of diabetes management also needs to be regulated during the school day. If children were following appropriate diabetes care, their insulin/medication regimen would need to be followed at school. This requires school staff to understand how to manage and assist in this care in order to support students with appropriate glycemic control and, thus, reduce the risk of long-term complications (Jackson et al., 2015). In adolescent students, improved school-based care improved diabetes management and quality of life (Wagner et al., 2006). Further, students who felt satisfied with the support they received in their school setting had lower HbA1c levels (Lehmkuhl & Nabors, 2008). School based care can include blood glucose monitoring, insulin administration, providing meals and snacks, recognizing and treating hypo- and hyperglycemia, and allowing for participation in physical activity (Jackson et al., 2015).

Conclusions

Youth with T1DM have been shown to exhibit more social-emotional problems when their HbA1c is not being controlled properly. Although the HbA1c marker is taken every 3 months, technology now offers real-time measurement of blood glucose levels, which could be linked more immediately to behaviors that youth are displaying. This advancement in technology has offered a better understanding about how glycemic control is impacting behavior in real-time. Research is still lacking about exactly how glycemic control impacts students' emotional and behavioral outcomes during their school days, especially using teachers as informants. Additionally, research has shown the positive impact that physical activity can have on physical and mental health. When youth get the recommended amount of physical activity, research has shown improvements in glycemic control, HbA1c, improved mood, and lower levels of emotional and behavioral problems. Physical activity may be able to enhance the behavioral outcomes of these youth. The purpose of this study is to examine the relations between glycemic control and teachers' reported behaviors of youth with T1DM and assess the impact physical activity has on teacher-reported behaviors. In addition, the mediational role that glycemic control has on physical activity and teacher-reported behaviors will be explored.

Chapter 3: Method

Participants

The current study sample was obtained from a broader randomized clinical trial that examined the effect of sleep modification on glycemic control in youth with T1DM. The parent grant for this dissertation study was funded by the American Diabetes Association grant #7-13-CE-32, and co-sponsored by the Order of the Amaranth Diabetes Foundation. Participants were recruited from an endocrinology clinic at a hospital in southwest Arizona by the Glucose Regulation and Neurobehavioral Effects of Sleep (GRANES) study (Perfect et al., 2016). Participants needed to be willing to complete the necessary measures and participate in the first baseline week of the study. Inclusion criteria included: a diagnosis of T1DM, ability to speak and understand English, and a consenting parent. Additionally, the participant needed to have been enrolled in school had at least one teacher complete the behavior rating scale. The parent study excluded those participants who had a developmental or psychiatric condition that interfered with participation or hospitalizations within one month of participation.

In total, there were 111 participants who enrolled in the study. After accounting for those who had Behavior Assessment System for Children, Second Edition, Teacher Report Scales (BASC-2 TRS), 92 participants were included in the analysis; sample sizes varied for each research question depending on the availability of sufficient CGM readings for the full week or during school, or if a child missed completing the physical activity questionnaire. Participants had a mean age of age 13.46 (SD = 2.11) with 46.7% being female (n = 49) and 53.3% being male (n = 49). Half of the participants identified as white/Caucasian (n = 46). Participants classified as minority status, for purposes of this study, primarily identified as Latinx (n = 29), with the remainder endorsing more than one race/ethnicity (n = 16). The median income based on census tract data using zip code was $48,587.00 (*SD* = 19511.65). Regarding parental education, 35.9% completed high school (*n* = 33), 29.3% completed partial college or received specialized training (*n* = 27), 19.6% received a bachelor's degree (*n* = 18), and 13.0% received a graduate degree (*n* = 12). The mean age at diagnosis was 8.48 years old (*SD* = 3.77). The mean number of years since diagnosis was 5.00 years (*SD* = 3.93). Of the included participants, 33.70% (*n* = 60) delivered insulin through an insulin pump and 65.20% (*n* = 31) delivered insulin through multiple dose injections. The demographic information of the participants is listed in Table 2 and Table 3.

Table 2

Means and Standard Deviations of Participant Characteristics

Variables	*n*	*M*	S*D*
Age	92	13.46	2.11
Age at T1DM diagnosis (months)	92	8.48	3.77
Years since T1DM diagnosis (months)	92	60.17	9.17
HbA1c	88	8.94	1.81
Median Income by Zip Code	92	52115.96	19511.65

Table 3

Participant Demographic Characteristics

Measure	*n*	%
Sex		
Male	49	53.3
Female	43	46.7
Ethnicity		
White	46	50.0
Minority	45	48.9
Median Household Income (self-reported)		
$10,000-$35,000	24	26.0
$35,000-$75,000	28	30.4
$75,000-$99,000	18	19.6
$100,000 or more	19	20.7
Highest Level of Parental Education		
Less than 7th Grade	8	8.7
8-11th Grade	9	12.0
High School Graduate	14	15.2
Partial College or Specialized Training	27	29.3
Bachelor’s Degree	18	19.6
Graduate Degree	12	13.0
504 Accommodations		
Yes	44	47.8
No	36	39.1
Special Education or 504		
Yes	60	54.1
No	40	36.0
Insulin Delivery Method		
Multiple Dose Insulin Injection	31	33.7
Insulin Pump	60	65.2
Body Mass Index		
Normal	59	64.1
Overweight	15	16.3
Obese	16	17.4

Note: The race/ethnicity background for those classified as minority include Latinx (*n* = 29), with some of whom endorsed more than one race/ethnicity (n = 16).

Measures

The following measures were collected as part of the broader study. The measures described below pertain to this current study.

Medical Records

The participants' archival health data were retrieved from the medical records of the doctor visits before and/or after participation in the research study. Medical records provided the T1DM diagnosis date, health history, any other medical conditions, insulin delivery method, and HbA1c values. The HbA1c values, obtained through a blood sample according to clinical guidelines, that occurred within 3 months prior to participation were most often used, as to minimize any effects the research had on their diabetes management. However, if there was not an HbA1c value obtained in the 3 months prior to participation, the HbA1c values taken 3 months after participation were used (Frye, Perfect, & Silva, 2019). HbA1c continues to be the standard in how glycemic control is monitored. The ADA (2020) suggests that HbA1c levels should be below 7.5% in youth to be considered in good diabetes control.

Demographic Health Interview

The participants' parents completed a Demographic Health Interview questionnaire. The information received from the questionnaire included information such as race/ethnicity, self-reported annual income range ($10,000-$35,000; $35,000-$75,000; $75,000-$99,000; and $100,000 or more), additional diagnoses, and some school related items such as special education status and if the participant had any behavioral problems at school. In addition to this questionnaire, household income was estimated by entering their zip code into the US Census Bureau database, which provided their median neighborhood income.

School Measures

Attendance was collected through school records. This information was used to verify the student was in school for at least two days during the week of the study. In addition, information was collected on each school's start and end times to isolate the hours each participant was at school.

Behavior Assessment System for Children, Second Edition, Teacher Report Scale (BASC-2 TRS)

The BASC-2 questionnaires were developed for children aged 2.0-21.11 to assist in assessing emotional, and behavioral difficulties. The rating scale is separated into different forms based on age groups. For this study, the child (ages 6-11) and adolescent (ages 12-21) forms from the Teacher Rating Scale (TRS) will be used. The TRS consists of the following composite scales: Externalizing Problems, Internalizing Problems, School Problems, Behavioral Symptoms Index, and Adaptive Skills. Each of the composites have various subscales. There are 139 TRS items, which are formatted on a Likert scale (1: never, 2: sometimes, 3: often, 4: almost always). Based on the answers, t-scores are formulated, with a mean of 50 and a standard deviation of 10. T-scores on the clinical scales that range from 60-69 are considered At-Risk and scores 70 and above are considered Clinically Significant. The BASC-2 was normed using the U.S. census population using a general population sample and a clinical sample. The general population sample consisted of 4,650 teacher ratings. The BASC-2 has an internal consistency of .80 in children and .90 in adolescents (Reynolds & Kamphaus, 2004). Test-retest reliability yielded a mean of 0.80 for the composite scores. Interrater reliability ranged from .53 to .82 on the TRS. The TRS was compared to various behavioral assessment tools. Correlations among the subscales ranged from .70-.80 when compared to similar constructs. For this study, the following sub scales were used: anxiety, depression, hyperactivity, aggression, and conduct problems.

Continuous Glucose Monitor (CGM)

An iPro2 Recorder (iPro2) was used as the continuous glucose monitoring device, which tracked glucose levels. The CGM included a glucose sensor that was inserted subcutaneously. The sensor connected to a lightweight monitor. The CGM sensor measured glucose every five minutes, with a range of 40-400 milligrams per deciliter (mg/dl). The monitor collected and stored the data until it was removed and downloaded to a computer after about a week (Kaufman et al., 2001). The participants were unable to see the readings while wearing the device. In order to calibrate the CGM, a minimum of four meter readings per day were required. The data that was used in this study included average glucose levels during school hours during the week, average glucose levels during the overall week, and the percentage of time spent in certain glucose level categories (hypoglycemia, hyperglycemic, in-target).

Table 4

Glucose Level Categories

Category	Plasma glucose concentration reported in milligrams per deciliter (mg/dL)
Hyperglycemic	>180 mg/dL
Suboptimal	>140-179 mg/dL
In-Target	70-140 mg/dL
Hypoglycemic	<70 mg/dL

(Knight & Perfect, 2019)

Block Kids Physical Activity Screener

The Block Kids Physical Activity screener is a self-report screener about the participant's physical activity. The screener assessed activities that the participant engaged in such as leisure time, school activities, chores, any jobs the participant had, as well as the amount of time engaging in sedentary activities such as watching television, playing video games, and being on the internet. In addition, the screener asked about participation in exercise. Questions inquired about the frequency and duration of the tasks during the last 7 days. For example, one question asked, "How many days did you do this kind of activity in the last 7 days?" Various activities were listed, such as: walking to school, walking the dog, dancing, or playing games with friends like tag, hide-and-go-seek, or hopscotch. Participants answered the frequency in which they engaged in activities with the following options: Never; 1 day; 2 days; 3-4 days; 5-6 days; or every day. Participants were then asked about the length of time they engaged in the activities. The duration options were as follows: less than 30 minutes; 30-60 minutes; 1-2 hours; 3 or more hours (Block et al., 2009).

With the benefits of moderate to vigorous physical activity well known, Block et al. (2009) sought to understand the benefits of lower intensity physical activity. Block et al. developed a questionnaire that also encompassed those lower intensity physical activities along with the higher intensity activities. In their research on adults, the authors attempted to better understand occupational, home, leisure, and sedentary activities. Their findings showed 1) when participants reported engaging in more physical activity, it significantly correlated with lower body fat; and 2) the energy expenditure found in the author's study was approximately equivalent to energy expenditure found in other studies. That questionnaire was used as a validation study in the development of the Block Physical Activity Assessment tool. The Block Physical Activity Screener provides estimates of energy expenditure through kilocalories (Kcal), minutes spent engaging in moderate physical activity in a week, and minutes spent engaging in vigorous activity in a week.

Procedures

Approval from the Institutional Review Board (IRB) was obtained and approved through the broader study completed by Perfect et al. (2016).

Recruitment

Recruitment took place over a three-year period. During a visit with doctors at an endocrinology clinic, a staff member involved in clinical care asked potentially eligible patients for permission to have a team member tell them about the study. If interested, a researcher further discussed the requirements for participation in the study and scheduled the potential participant for the consent visit. If a research team member was unable to speak with the patient, their contact information was collected so a researcher could contact them over the phone to assess their interest and schedule the consent visit. Data were collected to determine any patterns in those who declined to participate and those who did participate. Participants enrolled in the study for up to two weeks, with the first week referred to as the Naturalistic Sleep week and the second week referred to as the Sleep Modification week. During those weeks, three clinic visits occurred, two school visits, and one home visit.

Consent/Initial Visit

During the initial visit, a researcher reviewed the requirements for participation in the study and obtained written informed consent from the parent(s) and assent from the participant. Demographic information was collected, and parents signed a release of information to allow for the collection of the teacher rating scale data and allow for schools to send the participant's school records.

Once the consent process was completed, a CGM sensor was inserted subcutaneously into the fatty tissue of the abdomen or buttocks of the participant. The area was first cleaned using an alcohol wipe and an insertion device was used to insert the sterile, single use sensor. The electrode sensor remained under the skin and an iPro2 Recorder (iPro2) was connected to the sensor to continuously record glucose levels for up to 7 days. A dressing was then placed over the iPro2 to secure the device. The iPro2 recorded blood glucose levels every five minutes and stored the readings until the iPro2 was removed and the data was downloaded to the iPro2 software. The data retrieved included momentary glucose levels, average glucose levels, percentage of time spent hypoglycemic, hyperglycemic, and glucose variability.

A blood glucose meter and a box of 50 testing strips were provided to the participants. The researchers asked that the participants tested their blood at least 4 times per day. Approximately one hour after the iPro2 was inserted, participants tested their blood glucose levels using the new meter. This was to ensure their understanding of the use of the new meter and to calibrate the iPro2 sensor data.

The participant and parent identified two teachers who could be contacted as a part of the research study. A primary teacher was coded for youth with more than one teacher who responded. The primary teacher was asked to complete the BASC-2 (TRS) was the teacher who knew the child the longest. If both teachers knew the student for an equal amount of time, the teacher who had the student for a core academic subject was chosen to complete the questionnaire. If that teacher's data could not be used due to incomplete or missing BASC-2 (TRS) information, the alternative teacher's data was utilized.

A research team member contacted teachers Monday evening and/or Tuesday morning via email and phone. Researchers planned a meeting time on Friday for the teachers to complete the questionnaire about the participant. When meeting with the teacher(s), the researcher referred to the participant as being enrolled in a university-based program. Details were not provided about the program or the student's health status (though most teachers were aware the student had diabetes). The teacher(s) completed the BASC-2 (TRS) during the meeting and were instructed to focus on their observations of behaviors and interactions with the student.

At the end of the Naturalistic (Week 1/Baseline) week, participants returned to the endocrinology clinic for a complete neurobehavioral evaluation. This included the Block Kids

Physical Activity, which was administered to the participant on the computer. If needed, questions could be read aloud to the participant. The CGM sensor and monitor were removed, and the data were downloaded. Meter data were also downloaded to serve as a calibration measure.

Statistical Analysis

The statistical analysis was completed using SPSS, Version 27 data analysis software. Sex, minority status, BMI, annual household income by zip code, insulin delivery method (pump vs. injection), and years since diagnosis served as controls. If there was a need to correct for missing data, a pairwise correlation was completed.

Research Questions and Hypotheses

1. Does the strength of the relationship between teacher-reported behaviors (anxiety, depression, hyperactivity, aggressivity, conduct) of youth with T1DM differ based on varying metrics of glucose (average CGM-measures glucose levels during school hours, glucose average during overall week, percent time hyper/hypo-glycemic vs. in-target, and HbA1c)?
    a. Hypothesis 1a: Above and beyond socio-demographic (sex, race/ethnicity, BMI, annual household income) and diabetes related variables (insulin delivery method and years since diagnosis), average glucose levels over a week during the school hours will contribute a higher percentage of variance in teacher-reported behaviors than average glucose levels over a full week.
    b. Hypothesis 1b: Above and beyond socio-demographic and diabetes related variables, percent time in target range during school hours will contribute a higher

percentage of variance in one or more teacher-reported behaviors than glucose average during school.

c. Hypothesis 1c. Above and beyond socio-demographic and diabetes related variables, CGM metrics (average CGM-measures glucose levels during school hours, glucose average during overall week, percent time hyper/hypo-glycemic vs. in-target) will contribute a higher percentage of variance in one or more teacher-reported behaviors than HbA1c.

The first aim of the study was to determine if more precise measurements of glycemic control are more predictive of student behavior, as rated by their teachers. The behavioral outcomes that were examined included the Anxiety, Depression, Hyperactivity, Aggressivity, and Conduct scales as measured by the BASC-2 (TRS). Predictors included the varying metrics of glucose (glucose average during school hours over a week, glucose average during overall week, percent time hyper/hypo-glycemic vs. in-target, and HbA1c). Prior to conducting a hierarchical multiple regression, the relevant assumptions, which included a linear relationship, normal distribution, no multicollinearity, and homoscedasticity, were examined (Osborne & Waters, 2002). Due to the overlapping values, each CGM metric was examined in separate models to determine the proportion of variance for which it was contributing. Extreme univariate outliers were identified in initial data screening and were reviewed to determine whether they need to be removed or modified.

A three-step hierarchical multiple regression analysis was planned to determine if the glucose metrics (i.e., independent variables) had a significant influence on behaviors (i.e., dependent variables), after controlling for socio-demographics and diabetes-related variables. When conducting the hierarchical multiple regression, the first block included any sociodemographic variables (sex, race/ethnicity, BMI (z-score), median income determined by zip code) that significantly correlated to the respective BASC-2 scores at the bivariate level. Originally, analysis planned to have a second block, which would have included diabetes related variables (insulin delivery method (pump vs. injection), and years since diagnosis); however, none of these variables related to the BASC-2 scores for which models were conducted. The final block included an individual CGM metric that was being examined for the proportion of variance contributing to the BASC-2 subscale.

An ANOVA table indicated the degree to which the set of variables in the model significantly predicted the outcome. Additionally, the t-statistic reflected whether a particular variable significantly contributed to the model (i.e., added its own unique variance), and ß weights showed the standardized regression coefficient, akin to a correlation, but controlled for the other variables in the model. The strength of the relationship, explanatory power, or effect size was reported with R^2, which showed the proportion of variance explained by all variables in the model. The change in R^2 (converted to a percent by multiplying by 100%) showed the amount of variance contributed by the glucose metrics beyond demographics and diabetes-related variables. The unstandardized coefficients reflect the degree to which a one-unit change in the predictor corresponds to a change reflected by the coefficient in the outcome variable (Mendard, 2004).

For each hypothesis, regression models were run if at least one of the glucose metrics being compared was significant, even if the other one was not to allow for reporting of the proportion of variance the individual metric contributed to the respective BASC-2 subscale. Given this research question asked about the relationship between glucose metrics and teachers-reported behaviors, exploratory analyses using Pearson-product moment correlations, relative associations of various metrics of glycemic control and teacher-reported behaviors. These bivariate relationships provide important data given the clinical utility of the BASC-2 in characterizing the behaviors beyond those targeted in the hypotheses, the utility of the scales to support special education eligibility determinations, and the BASC's application to create targeted interventions.

2. Does physical activity in youth with T1DM predict one or more teacher-reported behaviors (anxiety, depression, hyperactivity, aggressivity, conduct)?

Hypothesis 2a: Above and beyond socio-demographic and diabetes related variables, physical activity (energy expenditure measured by mean kilocalories) will predict one or more teacher-reported behaviors (anxiety, depression, hyperactivity, aggressivity, conduct).

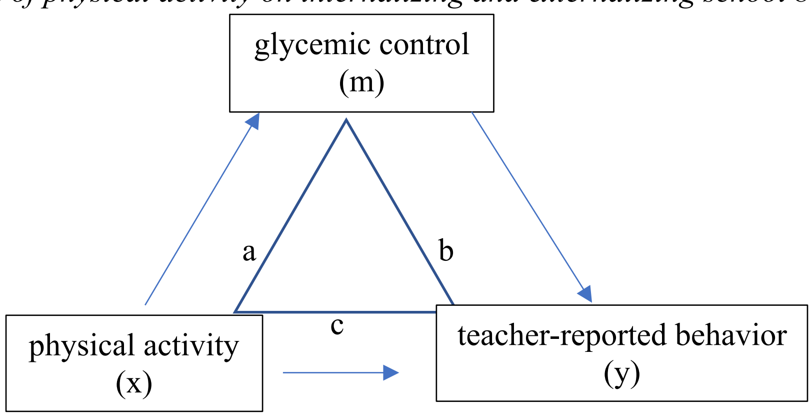
The second aim of the study was to determine the effects of physical activity on behavior, as rated by their teachers. The analytic plan was to first pretest the correlations between physical activity levels as measured through kilocalorie expenditure collected through the Block questionnaire and the sociodemographic characteristics, diabetes-related variables, and the behavioral outcomes (Anxiety, Depression, Hyperactivity, Aggressivity, and Conduct) that were examined as measured by the BASC-2 (TRS). For any BASC-2 score for which physical activity was related, hierarchical multiple regression analyses were planned as described for the first research questions, with Kcals as block 3 instead of glucose metrics.

3. Does glycemic control mediate the relations between physical activity and teacher-reported behavior (anxiety, depression, hyperactivity, aggressivity, and conduct)?

Hypothesis 3a. Glycemic control will mediate the relationship between physical activity and one or more teacher-reported behaviors (anxiety, depression, hyperactivity, aggressivity, conduct).

The third research question examined the mediational role that participant's glycemic control had on physical activity and behavior. In a mediation model, there are two pathways in which the independent variable (x) affects the dependent variable (y). The independent variable (x) can have an effect on the dependent variable (y) directly, which is considered a direct effect. An indirect effect represents an effect that occurs when the independent variable (x) passes through the mediating variable (m) and then onto the dependent variable (y). In other words, it is hypothesized that physical activity influences glycemic control, which influences teacher-reported behavior (Hayes, 2012).

Figure 1
Mediation model using the mediating effect of glycemic control on the relationship between physical activity and internalizing and externalizing school behavior (anxiety, depression, hyperactivity, aggressivity, and conduct). a is the effect of physical activity on glycemic control; b is the effect of glycemic control on internalizing and externalizing school behavior; c is the effect of physical activity on internalizing and externalizing school behavior.



Chapter 4: Results

Descriptive Statistics on Glucose Levels and Behavior

Table 5 shows the descriptive metrics for glycemic control used in the study. Regarding average HbA1c, the sample had a mean of 8.94% (*SD* = 1.81), which is above the ADA recommendations of 7.0%. Consistent with the HbA1c value, the average glucose levels were in the chronic hyperglycemic range. Average glucose levels across the full week (AvWeek; *M* = 205.41mg/dL, *SD* = 52.34) did not significantly differ from average glucose during school hours (AvSchool; *M* = 210.71mg/dL, *SD* = 62.40). The percent time in target range across the full week (%TargetWeek; *M* = 27.01%, *SD* = 21.00), percent time in target range during school hours (%TargetSchool; *M* = 24.30%, *SD* = 22.56), percent time hypoglycemic across the full week (Hypo%; *M* = 4.42%, *SD* = 5.83), and percent time hyperglycemic across the full week (Hyper%; *M* = 68.40%, *SD* = 24.44).

Table 5

Mean Scores, Standard Deviations, and Ranges on the Glucose Measures

Glucose Measure	Mean	SD	Minimum	Maximum
CGM AvWeek	205.41	52.34	84.00	332.00
CGM AvSchool	210.72	62.41	82.29	385.05
CGM %TargetWeek	27.01	21.01	1.00	97.00
CGM %TargetSchool	24.31	22.56	.00	96.73
CGM Hypo%	4.42	5.83	.00	32.00
CGM Hyper%	68.40	24.45	1.00	99.00
HbA1c	8.94	1.81	5.40	13.00

Note: Average glucose levels across the full week (AvWeek)
average glucose during school hours (AvSchool)
percent time in target range across the full week (%TargetWeek)
percent time in target range during school hours (%TargetSchool)
percent time hypoglycemic across the full week (Hypo%)
percent time hyperglycemic across the full week (Hyper%)

Table 6 shows the BASC-2 descriptives. The scores on the five hypothesized BASC-2 subscales were consistently in the Average Range: Anxiety (*M* = 47.71, *SD* = 10.04), Depression (*M* = 48.55, *SD* = 9.35), Hyperactivity (*M* = 48.45, *SD* = 8.32), Aggressivity (*M* = 47.00, *SD* =

8.41), and Conduct Problems (*M* = 46.78, *SD* = 8.15). These BASC-2 subscales had the following percentages of the sample population in the At-Risk or Clinically Significant range: Anxiety (At-Risk = 7.6%; Clinically Significant = 3.3%), Depression (At-Risk = 12.0%; Clinically Significant = 3.3%), Hyperactivity (At-Risk = 8.7%; Clinically Significant = 2.2%), Aggression (At-Risk = 3.3%; Clinically Significant = 4.3%), and Conduct (At-Risk = 3.3%; Clinically Significant = 2.2%).

Table 6

Mean Scores, Standard Deviations, and Ranges on the Behavior Assessment System for Children, Second Edition, Teacher Report Scale (BASC-2 TRS)

Scale Name	Mean	SD	Range	At-Risk %[c]	Clinical %[d]
Externalizing Composite[a]	47.21	8.26	41 - 96	3.3	2.2
Hyperactivity	**48.46**	**8.33**	**41 - 93**	**8.7**	**2.2**
Aggression	**47.00**	**8.41**	**43 - 89**	**3.3**	**4.3**
Conduct Problems	**46.78**	**8.15**	**42 - 99**	**3.3**	**2.2**
Internalizing Composite[a]	52.03	10.26	39 - 96	13.0	6.5
Anxiety	**47.72**	**10.05**	**38 - 91**	**7.6**	**3.3**
Depression	**48.55**	**9.35**	**42 - 86**	**12.0**	**3.3**
Somatization	58.48	12.94	43 - 108	22.8	18.5
School Problems	49.56	9.09	37 - 77	10.8	1.8
Attention Problems	49.89	9.45	37 - 75	14.1	2.2
Learning Problems	48.28	9.09	40 - 85	10.9	3.3
Behavioral Symptoms Index[a]	48.04	8.38	39 - 76	6.5	3.3
Atypicality	48.15	7.14	43 - 85	4.3	2.2
Withdrawal	48.45	8.56	38 - 72	10.9	2.2
Adaptive Skills[b]	51.12	10.07	31 - 70	10.9	0.0
Adaptability	50.86	8.94	31 - 67	14.1	0.0
Social Skills	51.01	11.39	28 - 72	15.2	2.2
Leadership	52.11	10.10	30 - 73	16.3	1.1
Functional Communication	51.09	9.13	29 - 66	12.0	1.1
Study Skills	49.77	9.81	30 - 66	16.3	1.1
Content Scales					
Anger Control [a]	48.34	8.92	35 - 74	5.4	3.3
Bullying [a]	48.11	9.10	40 - 103	6.5	2.2
Developmental and Social Disorders [a]	48.72	9.20	32 - 69	12.0	0.0
Emotional Self Control [a]	48.05	7.85	39 - 77	3.3	4.3
Executive Functioning [a]	47.13	7.81	39 - 80	5.4	2.2
Negative Emotionality [a]	48.87	9.10	35 - 78	7.6	4.3
Resiliency [b]	49.97	9.27	27 - 72	13.0	3.3

Note. BASC-2 Behavior Assessment System for Children, Second Edition.
Within Normal Limits are T-scores = 41-59
At-risk scores are T-scores = 60-69 or 31-40
Clinically Significant Scores are T-scores $\geq$70 or $\leq$30
[a] = Higher scores reflect more problem on these Composites and/or subscales;
[b] = Lower scores reflect more problems on these composites and/or subscales

Correlations of Sociodemographic Characteristics and Disease Variables with Behavior

Table 7 shows the correlations of the sociodemographic with the BASC-2 scores. The sociodemographic variables that were significantly correlated with the BASC-2 subscale were entered into the regression. The significant correlate for BASC-2 Depression scores was median income. The significant correlate for BASC-2 Anxiety scores was minority status (white vs. those who endorsed having a minority background). The significant correlate for BASC-2 Hyperactivity scores was sex. The significant correlates for BASC-2 Aggression and Conduct Problems scores were sex and median income.

Table 7

Pearson Correlation Matrix of BASC-2 and Sociodemographic and Diabetes-Related Variables

Variables	BASC-2 Anxiety	BASC-2 Depression	BASC-2 Hyper-activity	BASC-2 Aggression	BASC-2 Conduct Problems
Age	-.05	.04	-.07	-.16	-.14
Sex	-.04	-.13	-.35**	-.28**	-.27**
Race	.23*	.11	.01	.09	.19
BMI	-.02	.02	.10	.05	.06
Median Income (by zip code)	-.19	-.25*	-.20	-.24*	-.33**
Highest Parent Education	-.07	-.03	.03	.06	-.05
Special education status	-.03	-.03	.06	.16	.07
Insulin delivery method	.02	-.004	-.02	.08	.04
Age of diagnosis	.10	.0003	-.07	-.15	-.11
Years since diagnosis	-.11	.05	.03	.07	.04

Note: + indicates significance at a level less than .1, suggesting a trend towards significance
*indicates significance at a level less than or equal to .05
**indicates significance at a level less than or equal to .01
***indicates significance at a level less than or equal to .001

Research Question 1

The first research question examined the relationship between different indices of glycemic control (average glucose levels across the full week, average glucose during school hours, percent time in target range across the full week, precent time in target range during school hours, percent time hyperglycemic across full week, percent time hyperglycemic across the full week, and HbA1C) and internalizing and externalizing school behaviors (Anxiety, Depression Hyperactivity, Aggression, and Conduct Problems). There were three sub-hypotheses that further predicted that certain glucose variables would have stronger relationships than others.

Hypothesis 1a predicted that average glucose levels over a week during the school hours would contribute a higher percentage of variance in teacher-reported than average glucose levels across the week. Using Pearson product-moment correlations, average glucose levels over the week (AvWeek) were significantly, positively correlated to BASC-2 teacher reported depressive symptoms, $r(90) = .23$, $p = .029$. Moreover, CGM AvWeek was positively related with BASC-2 Anxiety, though the correlation did not reach significance, $r(90) = .18$, $p = .088$. CGM AvWeek over the full week did not significantly relate to the three Externalizing Composite behaviors: BASC-2 Hyperactivity, $r(90) = .08$, $p = .431$; BASC-2 Aggressivity, $r(90) = .05$, $p = .628$; and BASC-2 Conduct Problems, $r(89) = .06$, $p = .606$.

Average glucose during school hours (AvSchool) were significantly, positively correlated to teacher reported anxiety symptoms, $r(80) = .25$, $p = .026$. However, AvSchool was not significantly related to the following teacher-reported behaviors: BASC-2 Depression, $r(80) = .15$, $p = .192$; BASC-2 Hyperactivity, $r(80) = -.01$, $p = .934$; BASC-2 Aggressivity, $r(80) = -.05$, $p = .648$; and BASC-2 Conduct Problems, $r(79) = -.01$, $p = .938$.

Table 8

Pearson Correlation Matrix of Glucose and Internalizing and Externalizing Behaviors

Variables	CGM AvWeek	CGM AvSchool	CGM %Target Week	CGM % Target School	CGM Hypo%	CGM Hyper%	HbA1c
BASC-2 Anxiety	.18^{+}	.25*	-.18^{+}	-.21^{+}	-.15	.19^{+}	-.02
BASC-2 Depression	.23*	.15	-.22*	-.16	-.12	.22*	.02
BASC-2 Hyperactivity	.08	-.01	.03	-.06	.15	-.01	.01
BASC-2 Aggressivity	.05	-.05	.03	-.02	.09	-.08	.05
BASC-2 Conduct Problems	.06	-.01	.06	-.06	.20	-.14	.06

Note: + indicates significance at a level less than .1, suggesting a trend towards significance
*indicates significance at a level less than or equal to .05
**indicates significance at a level less than or equal to .01
***indicates significance at a level less than or equal to .001
Average glucose levels across the full week (AvWeek)
average glucose during school hours (AvSchool)
percent time in target range across the full week (%TargetWeek*)*
percent time in target range during school hours (%TargetSchool)
percent time hypoglycemic across the full week (Hypo%)
percent time hyperglycemic across the full week (Hyper%)

Two regression models were run to determine how much variance the AvSchool contributed to predicting BASC-2 Anxiety scores above and above the sociodemographic and diabetes related variables. The first regression model determined how much variance AvWeek contributed to predicting BASC-2 Anxiety scores (see Table 9). Due to the significant bivariate relationships during pretesting, minority status was the only sociodemographic variable included in the model as Step 1. No disease variables were correlated with BASC-2 Anxiety scores so were not included in the model as Step 2. The hierarchical multiple regression revealed that at Step 1, minority status contributed significantly to the regression model, $F(1,89) = 5.83$, $p = .018$, accounting for 6.2% of the variation in BASC-2 Anxiety. Together, minority status and AvWeek explained a significant proportion of variance in BASC-2 Anxiety scores, $R^2 = .08$, $F(2, 89) = 3.72$, $p = .028$. In Step 2, those who were from minority backgrounds reported significantly higher BASC-2 Anxiety scores, *ß* = .23, *t*(89) = 2.21, *p* = .030. CGM AvWeek added 1.7% variance but did not uniquely predict BASC-2 Anxiety scores above and beyond minority status, *ß* = .13, *t*(89) = 1.3, *p* = .213.

The second regression model determined how much variance CGM AvSchool contributed to predicting BASC-2 Anxiety scores (see Table 10). The hierarchical multiple regression revealed that at Step 1, minority status contributed significantly to the regression model, *F*(1,79) = 4.87, *p* = .030, accounting for 5.9% of the variation in BASC-2 Anxiety. Together, minority status and CGM AvSchool explained a significant proportion of variance in BASC-2 Anxiety scores, R^2 = .10, *F*(2, 79) = 4.43, *p* = .015. In Step 2, minority status significantly predicted higher BASC-2 Anxiety, *ß* = .23, b *t*(79) = 2.08, *p* = .030. CGM AvSchool added 4.4% variance. AvSchool did not reach significance in predicting anxiety symptoms above and beyond minority status, *ß* = .21, *t*(79) = 2.0, *p* = .055. Based on the unstandardized coefficient, for every one-unit increase in glucose (i.e., 1 mg/dL), BASC-2 Anxiety would be expected to experience an increase by .04 units (i.e., .04 of a point). Hypothesis 1a was partially supported regarding BASC-2 Anxiety with CGM AvSchool adding more variance (4.4%) than CGM AvWeek (1.7%).

Table 9

AvWeek Contribution to BASC-2 Anxiety

Hierarchical Linear Regression Models Predicting BASC-2 Anxiety by Minority Status and CGM AvWeek (n=89)

Variable	Unstandardized Coefficient (B)	*SE*	*beta*	*t*	*p*-value	95% CI
Step 1						
Minority Status	4.98	2.06	.25	2.42	.018	.88 - 9.07
Step 2						
Minority Status	4.59	2.08	.23	2.21	.030	.46 - 8.72
Anxiety	.03	.02	.13	1.26	.213	-.02 - .06

Table 10

AvSchool Contribution to BASC-2 Anxiety

Hierarchical Linear Regression Models Predicting BASC-2 Anxiety by Minority Status and CGM AvSchool (n=79)						
Variable	Unstandardized Coefficient (B)	*SE*	*beta*	*t*	*p*-value	95% CI
Step 1						
Minority Status	4.98	2.26	.24	2.21	.030	.49 - 9.47
Step 2						
Minority Status	4.62	2.22	.23	2.08	.041	.19 - 9.05
Anxiety	.04	.02	.21	1.95	.055	-.001 - .07

Two regression models were also run to determine how much variance CGM AvWeek relative to CGM AvSchool contributed to predicting BASC-2 Depression. For the first model (see Table 11), as pretesting revealed that median income was the only sociodemographic variable significant at the bivariate level, it was included in the model as Step 1. No disease variables were correlated with BASC-2 Depression scores, so none were included in the model as Step 2. The hierarchical multiple regression revealed that at Step 1, median income contributed significantly to the regression model, $F(1, 90) = 6.62$, $p = .012$, accounting for 6.9% of the variation in BASC-2 Depression. Together, median income and AvWeek explained a significant proportion of variance in BASC-2 Depression scores, $R^2 = .10$, $F(2, 90) = 4.98$, $p =$ .009. In Step 2, lower median income significantly predicted higher depressive symptoms, $\beta = -.23$, $t(90) = -2.22$, $p = .029$. CGM AvWeek added 3.2% variance, though this metric did not significantly add its own unique variance in predicting BASC-2 Depression scores above and beyond median income, $\beta = .18$, $t(90) = 1.78$, $p = .078$. Using the unstandardized coefficients, each one unit decrease in CGM AvWeeklevels (i.e., 1 mg/dL) s in a .03 unit decrease in BASC-2 Depression scores (i.e., .03 of a t-score point).

The second model determined how much variance the CGM AvSchool contributed to predicting BASC-2 Depression scores (see Table 12). The hierarchical multiple regression revealed that at Step 1, median income contributed significantly to the regression model, $F(1, 80) = 6.85$, $p = .011$, accounting for 8.0% of the variation in BASC-2 Depression scores. Together, median income and AvSchool explained a significant proportion of variance in BASC-2 Depression scores, $R^2 = .12$, $F(2, 80) = 3.52$, $p = .019$. In Step 2, median income significantly predicted higher depression, $ß = -.27$, $t(80) = 4.05$, $p = .021$. AvSchool added 1.4% variance and did not significantly predict BASC-2 Depression scores above and beyond median income, $ß = .12$, $t(80) = 1.11$, $p = .270$. Regarding BASC-2 Depression, contrary to Hypothesis 1a's prediction that AvSchool (1.4%) would add more variance than AvWeek (3.2%) was not supported. In fact, the opposite was true with CGM AvWeek adding a higher percentage of variance in predicting BASC-2 Depression.

Table 11

AvWeek Contribution to BASC-2 Depression

Hierarchical Linear Regression Models Predicting BASC-2 Depression by Income and CGM AvWeek (n=89)						
Variable	Unstandardized Coefficient (B)	*SE*	*beta*	*t*	*p*-value	95% CI
Step 1						
Income	.00	.00	-.26	-2.57	.012	.00 - .00
Step 2						
Income	.00	.00	-.23	-2.22	.030	.00 - .00
Depression	.03	.02	.18	1.78	.078	-.004 - .07

Table 12

AvSchool Contribution to BASC-2 Depression

Hierarchical Linear Regression Models Predicting BASC-2 Depression by Income and CGM AvSchool (n=89)						
Variable	Unstandardized Coefficient (B)	*SE*	*beta*	*t*	*p*-value	95% CI
Step 1						
Income	.00	.00	-.28	-2.62	.011	.00 - .00
Step 2						
Income	.00	.00	-.27	-2.52	.014	.00 - .00
Depression	.02	.02	.12	1.11	.27	-.01 - .05

Hypothesis 1b predicted that percent time in target range during school hours would contribute a higher percentage of variance in one or more teacher-reported behaviors than glucose average during school. Although not significant, BASC-2 Anxiety negatively associated with %TargetSchool, $r(76) = -.21$, $p = .069$. CGM %TargetSchool was not significantly related to the other hypothesized BASC-2 behaviors: BASC-2 Depression, $r(76) = -.16$, $p = .166$; BASC-2 Hyperactivity, $r(76) = -.06$, $p = .584$; BASC-2 Aggressivity, $r(76) = -.02$, $p = .851$; and BASC-2 Conduct Problems, $r(75) = -.060$, $p = .618$.

As reported under Hypothesis 1a, AvSchool contributed 4.4% to the model predicting BASC-2 Anxiety scores. A regression model was run to determine how much variance the %TargetSchool contributed to predicting BASC-2 Anxiety scores above and above the sociodemographic and diabetes-related variables (see Table 13). The hierarchical multiple regression revealed that at Step 1, minority status contributed significantly to the regression model, $F(1,75) = 4.55$, $p = .036$, accounting for 5.8% of the variation in BASC-2 Anxiety. Together, minority status and CGM %TargetSchool explained a significant proportion of variance in BASC-2 Anxiety scores, $R^2 = .092$, $F(2, 75) = 3.70$, $p = .030$. In Step 2, those who reported being Non-White, were rated as having significantly higher levels of anxiety, $\beta = .23$, $t(75) = -2.04$, $p = .045$. CGM %TargetSchool added 3.4% variance, but did not uniquely predict BASC-2 Anxiety scores at a significant level above and beyond minority status, $\beta = -.19$, $t(75) = -1.65$, $p = .103$. Hypothesis 1b was not supported in regard to BASC-2 Anxiety with CGM %TargetSchool adding more variance (3.4%) than CGM AvSchool (4.4%). Contrary to the prediction, CGM AvSchool contributed a higher percent of the variance than %TargetSchool for BASC-2 Anxiety scores. Since both CGM AvSchool and %TargetSchool were not significantly related to any of the other four hypothesized behaviors, a regression model was not conducted.

Table 13

%Target School Contribution to BASC-2 Anxiety

Hierarchical Linear Regression Models Predicting BASC-2 Anxiety by Minority Status and %TargetSchool (n=75)

Variable	Unstandardized Coefficient (B)	*SE*	*beta*	*t*	*p*-value	95% CI
Step 1						
Minority Status	5.04	2.36	.24	2.13	.036	.33 - 9.75
Step 2						
Minority Status	4.78	2.34	.23	2.04	.045	.11 - 9.44
Anxiety	-.09	.05	-.19	-1.65	.103	-.19 - .02

Hypothesis 1c predicted that CGM metrics would contribute a higher percentage of variance in one or more teacher-reported behaviors than HbA1c. Using a Pearson correlation, results indicated that HbA1c was not significantly related to the five hypothesized BASC-2 behaviors: BASC-2 Anxiety, $r(88) = -.02$, $p = .826$; BASC-2 Depression, $r(88) = .02$, $p = .872$; BASC-2 Hyperactivity, $r(88) = .01$, $p = .372$; BASC-2 Aggressivity, $r(88) = .05$, $p = .618$; and BASC-2 Conduct Problems, $r(87) = .06$, $p = .574$.

The correlations of the AvSchool, CGM AvWeek, and %TargetSchool were previously reported when testing Hypothesis 1a and 1b (see Table 8). Using a Pearson correlation, %TargetWeek was significantly, negatively correlated to BASC-2 Depression scores, $r(90) = -.22.$, $p = .041$. Moreover, although not significant, CGM %TargetWeek negatively associated with BASC-2 Anxiety, $r(90) = -.18$, $p = .098$. CGM %TargetWeek did not significantly relate to the BASC-2 Externalizing Composite behaviors: BASC-2 Hyperactivity, $r(90) = .03$, $p = .813$; BASC-2 Aggressivity, $r(90) = .03$, $p = .753$; and BASC-2 Conduct Problems, $r(89) = .06$, $p = .058$.

A regression model was run to determine if CGM %TargetWeek significantly predicted BASC-2 Depression scores above and above the sociodemographic and diabetes related variables (See Table 14). Due to the significant bivariate relationships during pretesting, only median income determined via zip code was included in Step 1. Since none of the disease characteristics were related, they were not included in the model, so therefore, it was only a 2-step model. The hierarchical multiple regression revealed that at Step 1, median income contributed significantly to the regression model, *F*(1, 90) = 6.62, *p* = .012, accounting for 6.9% of the variation in BASC-2 Depression. Together, median income by zip code and CGM %TargetWeek explained a significant proportion of variance in BASC-2 Depression scores, R^2 = .09, *F*(2, 90) = 5.23, *p* = .007. In Step 2, lower median income significantly predicted higher depression, *ß* = -.25, *t(*90) = -2.44, *p* = .017. CGM %TargetWeek added 3.7% variance but this CGM metric did not reach significance in uniquely predicting BASC-2 Depression scores above and beyond median income, *ß* = -.19, *t*(90) = -1.91, *p* = .060.

Table 14

%TargetWeek Contribution to BASC-2 Depression

Hierarchical Linear Regression Models Predicting BASC-2 Depression by Income and %TargetWeek (n=90)

Variable	Unstandardized Coefficient (B)	*SE*	*beta*	*t*	*p*-value	95% CI
Step 1						
Income	.00	.00	-.26	-2.57	.012	.00 - .00
Step 2						
Income	.00	.00	-.25	-2.44	.017	.00 - .00
Depression	-.09	.05	-.19	-1.91	.060	-.18 - .004

Hypo% was not significantly related to the BASC-2 scubscales: BASC-2 Anxiety, *r*(90) = -.15, *p* = .155; BASC-2 Depression, *r*(90) = -.12 *p* = .245; BASC-2 Hyperactivity, *r*(90) = .15, *p* = .159; BASC-2 Aggressivity, *r*(90) = .09, *p* = .417; and BASC-2 Conduct Problems, *r*(89) = .20, *p* = .074.

Hyper% was significantly, positively correlated BASC-2 Depression, *r*(90) = .22, *p* = .041. Although not significant, Hyper% positively correlated with BASC-2 Anxiety, *r*(90) = .19, *p* = .069. Hyper% did not significantly relate to 3 Externalizing Composite behaviors: BASC-2

Hyperactivity, *r*(90) = -.01, *p* = .371; BASC-2 Aggressivity, *r*(90) = -.08, *p* = .433; and BASC-2 Conduct Problems, *r*(89) = -.14, *p* = .192.

Since Hyper% was related to BASC-2 Depression, a regression model was run to investigate its contribution to BASC-2 Depression scores above and above the sociodemographic and diabetes related variables (see Table 15). Due to the significant bivariate relationships during pretesting, the following sociodemographic and diabetes related variables were included in the model: median income. In Step 1, median income was included as a sociodemographic variable. Since none of the disease characteristics were related, they were not included in the model so therefore it was only a 2-step model. The hierarchical multiple regression revealed that at Step 1, median income contributed significantly to the regress on model, *F*(1, 90) = 6.62, *p* = .012, accounting for 6.9% of the variation in BASC-2 Depression. Together, median income by zip code and CGM Hyper% explained a significant proportion of variance in BASC-2 Depression scores, R^2 = .11, *F*(2, 90) = 5.23, *p* = .007. In Step 2, lower median income by zip code significantly predicted higher BASC-2 Depression, *ß* = -.25, *t*(90) = -2.44, *p* = .017. Hyper% added 3.7% variance but did not reach significance in predicting BASC- Depression scores above and beyond median income, *ß* = .19, *t*(90) = 1.90, *p* = .061.

Table 15

%Hyper Contribution to BASC-2 Depression

Hierarchical Linear Regression Models Predicting BASC-2 Depression by Income and %Hyper (n=90)

Variable	Unstandardized Coefficient (B)	*SE*	*beta*	*t*	*p*-value
Step 1					
Income	.00	.00	-.26	-2.57	.012
Step 2					
Income	.00	.00	-.25	-2.44	.017
Depression	.07	.19	.19	1.90	.061

Overall, it appears that CGM AvWeek, CGM %TargetWeek, and CGM Hyper% were stronger predictors than HbA1c for BASC-2 Depression. Similarly, CGM AvSchool was a stronger predictor than HbA1c for BASC-2 Anxiety scores. None of metrics tested had relationships with BASC-2 Externalizing Composite behaviors (Hyperactivity, Aggressivity, and Conduct Problems).

Exploratory Analyses. The exploratory analysis included a review of the relations between the other BASC-2 subscales with the CGM metrics. As seen on Table 16, CGM AvWeek was positively, significantly related to the following scales: Internalizing Composite, $r(90) = .29$, $p = .005$; Somatization, $r(90) = .28$, $p = .008$; School Problems, $r(90) = .26$, $p = .013$; Attention Problems, $r(90) = .25$, $p = .017$; Learning Problems, $r(90) = .23$, $p = .029$; and Anger Control, $r(90) = .21$, $p = .049$. CGM AvWeek was negatively related to Study Skills, $r(89) = -.21$, $p = .050$.

Table 16

Pearson Correlation Matrix for Exploratory Analysis

Scale Name	CGM Av Week	CGM Av School	CGM % Target Week	CGM % Target School	CGM Hypo%	CGM Hyper%	HbA1c
ernalizing Composite	**.07**	**-.03**	**.04**	**-.05**	**.15**	**-.11**	**.07**
Internalizing Composite	**.29****	**.24***	**-.24***	**-.20**	**-.18**	**.25***	**.05**
Somatization	.28**	.17	-.18	-.12	-.16	.19	.11
School Problems	**.26***	**.17**	**-.21***	**-.17**	**.04**	**.16**	**.10**
Attention Problems	.25*	.21	-.19	-.21	.08	.13	.15
Learning Problems	.23*	.11	-.20	-.10	-.02	.18	.03
Behavioral Symptoms Index	**.20**	**.12**	**-.13**	**-.16**	**.01**	**.09**	**.05**
Atypicality	.11	.11	-.09	-.15	-.003	.07	-.02
Withdrawal	.19	.15	-.12	-.12	-.11	.12	-.05
Adaptive Skills	**-.18**	**-.12**	**.11**	**.07**	**-.002**	**-.09**	**-.04**
Adaptability	-.14	-.10	.06	.07	-.07	-.02	-.06
Social Skills	-.19	-.16	.12	.10	-.004	-.10	-.05
Leadership	-.15	-.12	.12	.06	.02	-.11	.01
Functional Communication	-.15	-.009	.09	-.06	.08	-.10	-.04
Study Skills	-.21*	-.14	.12	.09	-.01	-.10	-.06
Content Scales							
Anger Control	.21*	.15	-.12	-.10	.02	.08	.08
Bullying	.05	-.001	.08	-.03	.18	-.16	.08
Developmental and Social Disorders	.21	.16	-.13	-.13	-.01	.11	.04
Emotional Self Control	.09	-.04	.003	-.005	.03	-.03	.06
Executive Functioning	.12	.05	-.04	-.12	.11	-.02	.10
Negative Emotionality	-.08	-.16	.04	.11	-.08	-.01	.04
Resiliency	-.05	.02	.05	-.09	.23*	-.11	-.01

Note: + indicates significance at a level less than .1, suggesting a trend towards significance
Average glucose levels across the full week (AvWeek)
average glucose during school hours (AvSchool)
percent time in target range across the full week (%TargetWeek*)*
percent time in target range during school hours (%TargetSchool)
percent time hypoglycemic across the full week (Hypo%)
percent time hyperglycemic across the full week (Hyper%)
*indicates significance at a level less than or equal to .05
**indicates significance at a level less than or equal to .01
***indicates significance at a level less than or equal to .001

Research Question 2

The second aim of the study was to determine the effects of physical activity on behavior, as rated by their teachers. It is recommended that youth engage in an hour of moderate to vigorous physical activity daily (Twisk, 2001). Table 17 shows that on average, the youth in this study reported engaging in an estimated 62.91 minutes (*SD* = 75.77) of moderate physical activity per day and 30.28 minutes (*SD* = 46.03) of vigorous physical activity per day, indicating that the average time spent met the daily physical activity recommendations. However, only 48% of the sample was getting the recommended 60 minutes of moderate to vigorous physical activity daily, with 38% of participants engaging in moderate activity and 15% engaging in vigorous activity. Several participants had noted that they were completely inactive.

Table 17

Means, Standard Deviations, and Ranges of the Block Physical Activity Screener

	Description	Mean	Standard Deviation	Minimum	Maximum
Kilocalories	Estimated energy expenditure for all activities	464.91	650.54	.00	5016.30
Moderate Mins	Estimated moderate activity minutes per day	62.91	75.77	.00	611.70
Vigorous Mins	Estimated vigorous activity minutes per day	30.28	46.03	.00	240.00

Table 18

Pearson Correlation Matrix of Physical Activity and Sociodemographic and Diabetes-Related Variables

Variables	Kcal
Age	.12
Sex	-.15
Minority Status	-.09
BMI	.26**
Median Income (by zip code)	.10
Highest Parent Education	-.02
Special education/504 Status	-.002
Insulin delivery method	-.26*
Age of diagnosis	.07
Years since diagnosis	.01

Note: Kilocalories (Kcal)
*indicates significance at a level less than or equal to .05
**indicates significance at a level less than or equal to .01
***indicates significance at a level less than or equal to .001

Physical activity as measured in kilocalories (Kcals) did not significantly relate to any of the hypothesized teacher reported behaviors (see Table 19): BASC-2 Anxiety, $r(90) = -.010$ $p = .351$; BASC-2 Depression, $r(99) = -.08$, $p = .452$; BASC-2 Hyperactivity, $r(90) = .06$, $p = .609$; BASC-2 Aggressivity, $r(90) = -.04$, $p = .740$; and BASC-2 Conduct Problems, $r(90) = -.02$, $p = .858$. As the bivariate correlations were not statistically significant, regression models were not run for the second research question.

Table 19

Pearson Correlation Matrix of Physical Activity and Internalizing and Externalizing Behaviors

Variables	Kcal
BASC-2 Anxiety	-.10
BASC-2 Depression	-.08
BASC-2 Hyper	.06
BASC-2 Aggressivity	-.04
BASC-2 Conduct	-.02

Note: $*p \leq .05$, $**p < .01$, $***p < .001$, $^{+} p \leq .10$

Research Question 3

The final hypothesis sought to understand the mediating role of glycemic control between physical activity in Kcals and teacher-reported BASC-2 behaviors (Anxiety, Depression, Hyperactivity, Aggressivity, Conduct). As can be seen in Table 20 and Figure 2, the unstandardized regression coefficient between physical activity (the IV) and CGM average across the week (the mediator) was not statistically significant, $a = -.002$, $t = -.20$, $p = .842$, 95% CI [-.018 - .015]. Results from the mediation analysis using the PROCESS model indicated that the total effect (effect of x on y, without m) of physical activity on BASC-2 Depression was not statistically significant, $c = -.001$, $t = -.73$, $p = .467$, 95% CI [-.004 - .002]. Finally, although the indirect effect of physical activity on BASC-2 Depression scores through AvWeek did not reach significance $c' = -.001$, t = -.70, $p = .486$, 95% CI [-.004 - .002], the mediator significantly predicted BASC-2 Depression scores $b = .04$, t = 2.05, $p = .044$, 95% CI [.001 - .076]. Thus, although physical activity was not significantly related, elevated glucose levels during week significantly predicted higher BASC-2 Depression scores. The unstandardized indirect effects computed for each of 10,000 bootstrapped samples resulted in a coefficient of -.0001, and a range -.002 to .001 at the 95% confidence interval. Given that the confidence interval crosses zero, the true indirect effect is estimated to be non-significant, indicating that average glucose levels across a week do not mediate the associations between physical activity and depressive symptoms.

Table 20

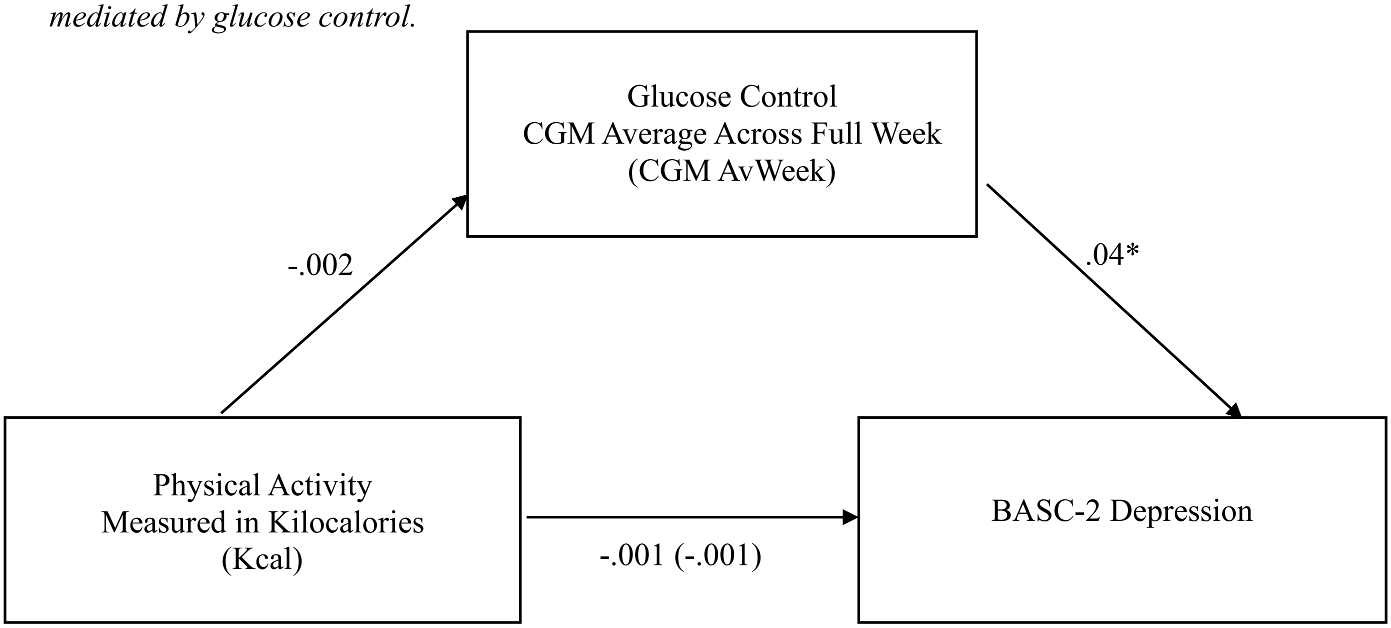
Mediational Model: Effect of Physical Activity on Depression, when Controlling for Glucose

	Coefficient	S.E.	t	*p*-value
(A path) Physical Activity -> Glucose (AvWeek)	−.002	.008	-.20	.842
(B path) Glucose (AvWeek) -> Depression	.04	.02	2.05	.044
(C path) Physical Activity -> Depression	-.001	.002	-.73	.467
(C′ path)* Physical Activity -> Depression	-.001	.002	-.70	.486

* Effect of Physical Activity on Depression, when controlling for Glucose (AvWeek)

Figure 2

Regression coefficients for the relationship between physical activity and BASC-2 Depression as mediated by glucose control.



Note: The regression coefficient between physical activity and depression is in parenthesis.
*p<.05.

As can be seen in Table 21 and Figure 3, the unstandardized regression coefficient between physical activity (the IV) and CGM AvSchool (the mediator) was not statistically significant, $a = -.02$, $t = -1.55$, $p = .125$, 95% CI [-.035 - .004]. Results from the mediation analysis using the process model indicated that the total effect (effect of x on y, without m) of physical activity on BASC-2 Anxiety was not statistically significant, *c* = -.002, *t* = -1.05, *p* = .295, 95% CI [-.005 - .002]. Finally, although the indirect effect of physical activity on BASC-2 Anxiety scores through AvSchool did not reach significance *c′* = -.001, *t* = -.72, *p* = .472, 95% CI [-.005 - .002], the mediator significantly predicted BASC-2 Anxiety scores *b* = .04, *t* = 1.91, *p* = .060, 95% CI [-.002 - .072]. A 95% bias-corrected confidence interval based on 10,000 bootstrap samples indicated that the indirect effect (*ab* = -.001) crossed zero (-0.003 to .0002).

Table 21

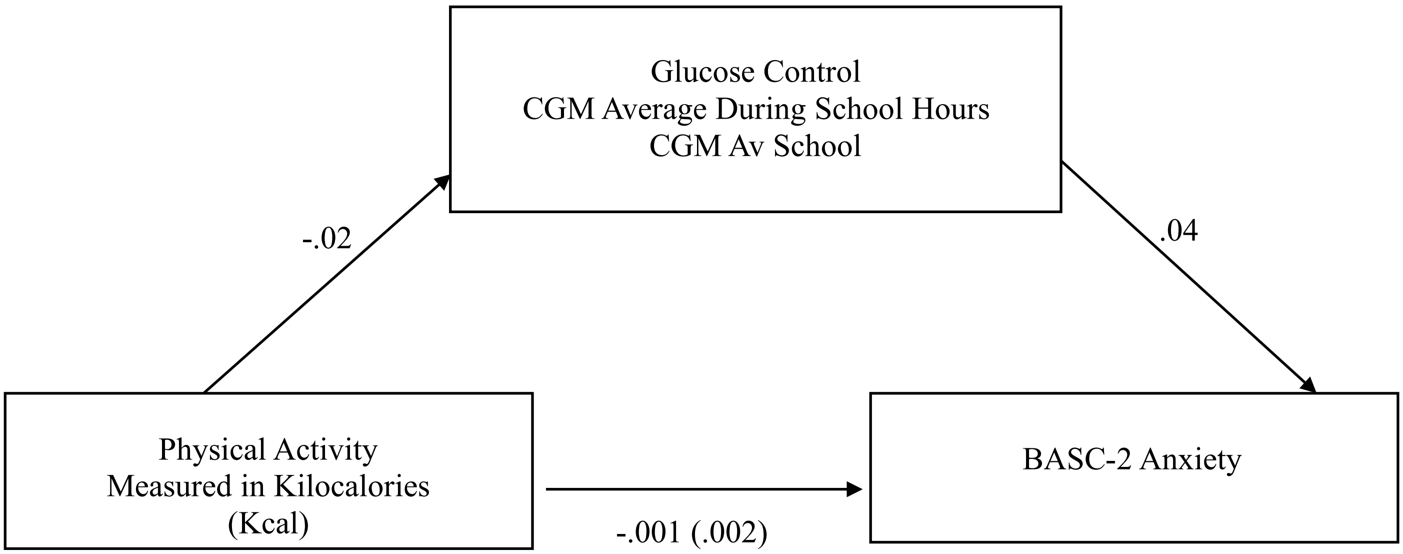
Mediational Model: Effect of Physical Activity on Anxiety, when Controlling for Glucose

	Coefficient	S.E.	t	*p*-value
(A path) Physical Activity -> Glucose (AvSchool)	-.02	.01	-1.55	.125
(B path) Glucose (AvSchool) -> Anxiety	.04	.02	1.91	.060
(C path) Physical Activity -> Anxiety	-.002	.002	-1.05	.295
(C′ path)* Physical Activity -> Anxiety	-.001	.002	-.72	.472

* Effect of Physical Activity on Anxiety, when controlling for Glucose (AvSchool)

Figure 3

Regression coefficients for the relationship between physical activity and BASC-2 Anxiety as mediated by glucose control.



Note: The regression coefficient between physical activity and anxiety is in parenthesis.
*p<.05.

Chapter 5: Discussion

This study investigated the mediating role that glycemic control played between physical activity and teacher-reported behavior. The five main teacher-reported behaviors targeted were two aspects of internalizing symptoms (anxiety, depression) and three dimensions of externalizing behaviors (hyperactivity, aggressivity, and conduct problems). Hypothesis 1a was partially supported as glycemic control isolated to the school hours contributed more variance in predicting anxious behaviors observed by teachers relative to the full week, whereas average glucose levels across the full week better explained teacher-reported depressive symptoms. Contrary to Hypothesis 1b, percent time in the target range during the school day did not have more explanatory power in predicting behaviors than the continuum of glucose levels recorded during school hours in predicting teacher-reported anxiety symptoms. The percent time in the target range reflects the degree of glycemic control. Per Hypothesis 1c, CGM metrics contributed a higher percentage of variance in one or more teacher-reported behaviors than HbA1c. Thus, glucose levels at school and over a week as well as more time spent experiencing elevated glucose levels appeared to correspond better to behaviors that manifest at school than HbA1c, which is a more global index of glycemic control over a three-month period. Contrary to expectations, physical activity was not related to teacher reported behaviors. The mediation analysis indicated that the total effect (effect of x on y, without m) of physical activity on depressive symptoms was not statistically significant. Finally, the indirect effect (effect of x on y, with m) of physical activity on depressive symptoms through average glucose across a week did not reach significance. However, supporting the results found in the first research question, elevated glucose levels during the week (the mediator) were significantly related to higher depressive symptoms.

Internalizing and Externalizing Behaviors in Youth with T1DM

Internalizing behaviors are conceptualized as disordered feelings and moods directed inward and associated with depression, anxiety, and anhedonia (Lau et al., 2019). In this sample, participants' BASC-2 Internalizing Composite mean was a T score of 52.03, with a standard deviation of 10.26. In this sample, the students' levels of anxiety and depressive symptoms appear comparable to same aged peers, with the mean scores in the Average range (T=47.72 for anxiety and T=48.55 for depressive symptoms) and with 10.9% and15.3% of scores in the At-Risk or Clinically Significant range. These scores as well as the rates of those who were in the At-Risk or Clinically Significant Range reflected that teachers rated the youths' behaviors consistent with their peers. In the current study, the BASC-2 Somatization was not examined because it may have been confounded by the participants' chronic illness. Indeed, the Somatization score was slightly elevated, suggesting that these youth tended to be overly sensitive to and complain about relatively minor physical problems and discomforts or that the teachers' response reflected the students' health-related issues (Vannest et al., 2015).

With the constant management of their diabetes inducing stress, noradrenaline and cortisol are activated, which can activate anxiety. Heightened cortisol levels can cause disturbances in the hippocampus, which is involved with depression (Bădescu et al., 2016). When compared to healthy controls, magnetic resonance images (MRI) have shown superior prefrontal cortical thickness reduction in individuals with T1DM (Lyoo, 2012). Additionally, the limbic structures have been shown to be affected in individuals with T1DM (McIntyre et al, 2010). With the prefrontal cortex and limbic structures affected, both the structural and biochemical disruption can lead to increased mental health issues (Van Duinkerken et al., 2020). Although brain structures and neurotransmitters were not examined in the study and need to be further explored in future research, these physiological processes may be the underlying mechanisms by which glycemic control and the internalizing symptoms of depression and anxiety were connected.

Externalizing behaviors are negative or maladaptive behaviors demonstrated in hyperactivity, noncompliance, aggression, etc. (Donenberg & Baker, 1993). The limited findings have been mixed as to whether youth with T1DM have higher levels or rates of externalizing symptoms. Some studies have found that parents reported higher levels of behavior problems in children with T1DM (Northam et al., 2006). Teachers in this study did not perceive that these youth with T1DM struggled with externalizing behaviors more than other children and adolescents as this sample had an Externalizing Composite mean in the Average range (T-score of 47.21). Nonetheless, as addressed below, the study did identify sociodemographic characteristics that related to both internalizing and externalizing symptoms, and glycemic control associations with anxiety and depression.

Sociocultural Context of Behaviors in Youth with T1DM

In this study, certain sociodemographic characteristics were significantly correlated with the five targeted teacher-reported behaviors. Participants who lived in zip codes with lower median incomes had significantly higher levels of depressive symptoms, aggression, and conduct problems as rated by the teachers. Participants who identified as a racial/ethnic minority had significantly higher anxiety symptoms. The findings in this study were similar to others that showed families without a child diagnosed with T1DM who experienced low-income showed increased rates of internalizing symptoms, specifically symptoms of depression and anxiety (Lorant, 2003; Melchior, 2010). Likewise, research has found that both anxiety and depressive symptoms were higher in ethnic minority groups (Schmidt et al., 2017). However, caution needs to be taken as teacher ratings may introduce bias ascribed to certain sociodemographic characteristics (e.g., race/ethnicity, gender, etc.) that impact their perception of behaviors (Zee & Rudasill, 2021).

Moreover, a past study found that poorer glycemic control was related to both depression and lower SES, with worsening glycemic control increasing the chances of depression (Bădescu et al., 2016). In a meta-analysis by Lorant et al. (2003), the association between depression and SES was interpreted as the result of stress and strain. The stress theory postulates that families experiencing low SES have fewer resources. The consequences may be limited coping skills, lower self-esteem, and more external locus of control, which indicates that these traits safeguard the impact of stress and depression. The strain theory focuses on community safeguards such as values, social welfare and cohesion, infrastructure, and public health access (Lorant et al., 2010). Moving forward, it is important to ensure that diverse populations are being examined in research studies (Karter et al., 2002). The disadvantages facing these groups are systematic and multifaceted. It is critical to ensure that there are more supports for minoritized populations and those who live in lower SES communities, particularly given the racial and economic disparities facing individuals with T1DM and mental health difficulties. For instance, Lipman and Hawkes (2021) contended that despite the strides made with diabetes technologies, youth with T1DM who identify as a racial/ethnic minority or are from lower SES strata have limited access to the devices needed to support their diabetes management. Researchers (Agarwai et al., 2020; Lipman & Hawkes, 2021) have argued that as part of mental health screening in youth with T1DM, clinical health care providers should identify and consider ways to mitigate risk factors, such as food or housing insecurity, inadequate insurance coverage, traumatic event exposure, etc. Further, school-based research may support more equitable access to disenfranchised populations who do not always make healthcare visits. Research in school environments would also provide ecologically valid data for documenting effective strategies that school personnel could incorporate into their services to support the learning and well-being of youth with T1DM.

Glycemic Control

The average glucose level of 210.95 mg/dL is considered to be severely hyperglycemic (Knight & Perfect, 2019) and places the youth at risk for ketoacidosis and future macrovascular (e.g., blindness, neuropathy) complications. This value is equivalent to 9.0% HbA1c. Participants in this study had an average glucose level of 205.41 across the full week and an average of 210.72 during school hours. Optimal blood glucose levels range from 70 - 140 mg/dL. Their HbA1c levels averaged 8.94. It is recommended that youth with T1DM have HbA1c levels below 7.50%. On average, participants were spending 68.40% of their time in the hyperglycemic range across the week, with only 24.31-27.01% of the time in the optimal range. As noted before, this sample was largely in the severe hyperglycemic range of diabetic control. If chronic hyperglycemia is left unaddressed, these individuals are at risk for chronic morbidities (e.g., retinopathy, hypertension, loss of limbs, etc.) and mental health challenges.

Research Question 1: Glycemic Control and Teacher-Reported Behaviors

The first aim of the study was to determine if more precise measurements of glycemic control (i.e., time dependent) were more predictive of student behavior, as rated by their teachers through the BASC-2 TRS. Ultimately, this aim sought to understand how temporal glucose impacts behavior. As described below, two of the three hypotheses were supported, as certain CGM metrics added a higher percentage of variance in predicting one or more teacher-reported behaviors. Overall, these findings suggest that glucose levels and behaviors observed at school have a small association, but that there are other aspects of glycemic control not evaluated in this study and other factors that contribute to externalizing and internalizing behaviors of youth with T1DM.

CGM Average over School Hours vs. Full Week

In this study, average glucose levels across the full week and average glucose during school hours both did not significantly relate to the three externalizing symptoms related to hyperactivity, aggressivity, or conduct problems. However, average glucose levels across the full week were significantly associated with teacher-reported depressive symptoms, and although not significant, positively correlated to teacher-reported anxiety symptoms. Even though CGM average glucose levels across the full week only added 3.2% variance, suggesting there are many other contributing factors, this may help understand one factor influencing students' depressive symptoms for this population. Showing the opposite pattern, average glucose during school hours were significantly related to teacher reported anxiety symptoms. These bivariate relationships held up in the multiple regression findings. The findings in this study are consistent with previous research that has shown higher levels of depression associated with poorer glycemic control (Hood et al., 2006). It is important to note that these associations can be looked at in two ways, with more depression leading to poorer diabetes management or the opposite (Hood et al., 2006).

Further examination of CGM averages revealed that the average glucose levels across the full week were significantly related to the following BASC-2 scales: Internalizing Composite, Somatization, School Problems, Attention Problems, Learning Problems, Anger Control, and Study Skills. The results of this study show that students with greater glycemic dysregulation appear to be struggling with school behaviors related to being able to attend, having good study strategies, and mastering material. In one of the few previous studies that have examined teacher-reported behaviors of youth with T1DM, Parent et al. (2009) showed that students with T1DM were rated as having poorer academic skills (reading, writing, and math) when compared to healthy siblings. Notably, the authors also found memory, task completion, and attention as being more problematic for students with T1DM when compared to controls. Unlike the current study that did not find HbA1c to be significantly correlated with teacher-reported behaviors, however, the most marked finding in that previous study was the link between glycemic control as measured by HbA1c and the ratings of inattention and academic skills (Parent et al., 2009). Rather in the current study that used CGM, weekly average glucose levels related to attention. Additionally, with regard to the sample from Parent et al. (2009), the majority of participants were White, Non-Hispanic and they had a broader age range (6 – 17 years old), though they had a similar income profile.

CGM Average over School Hours vs. % Time in Target Range during School

Average glucose during school hours were significantly related to teacher reported anxiety symptoms. In contrast, CGM percent time in target range during school hours was not significantly related to the hypothesized internalizing and externalizing behaviors. Although knowing average glucose levels is beneficial, these estimates may be misleading as they do not adequately depict variability in glycemic levels (Beck et al., 2019). Beck et al. (2019) suggested that time in target range is easily understood, has been shown to be an important factor in diabetes management by providing an indirect measurements of hypo- and hyperglycemia. It may be helpful for teachers to understand that it is possible that one student may experience variability in their glucose levels, yet those high and low levels, produce an average level that as value gives the impression the student’s diabetes is well-managed. Another student who has the same mean glucose level, may consistently have blood glucose levels in the optimal range. The amount of time that students spend in the target range captures how much time their glucose levels were optimal, though in the case of this study did not yield greater explanatory power in predicting the behaviors reported by the teachers than average glucose levels during school.

Glucose Measures via CGM vs. HbA1c

Results indicated that HbA1c and percent time hypoglycemic across the full week did not significantly relate to any of the five hypothesized BASC-2 behaviors. However, as hypothesized, several of the CGM metrics did significantly correlate with either teacher-reported depression or anxiety symptoms, adding a higher percent of the variance in predicting these two subscales relative to HbA1c. Specifically, in addition to average glucose levels across the full week as noted above, CGM percent time in target range across the full week (negative direction) and percent time hyperglycemic across the full week (positive direction) contributed more variance than HbA1c in predicting teacher-reported depressive symptoms. Although HbA1c is strongly indicative of diabetes disease course and subsequent morbidities, it misses information about momentary fluctuations (Gross & Mastrototaro, 2000l; Wilmot et al., 2019). Since HbA1c only produces a weighted average of glucose levels over a three-month period, it is believed that the CGM has an advantage over HbA1c in tracking how glucose levels and changes correspond to behavioral patterns and performance on a day-to-day basis (Gross & Mastrototaro, 2000). Based on these findings, the benefits of incorporating CGM devices into routine diabetes management may not only to be to provide continuous feedback on glucose levels, but also because of the potential correspondence of glucose levels and behaviors or academic functioning closer in time such as observed in this study and previous studies (e.g., Knight & Perfect, 2019).

In the current study, glycemic control did not significantly relate to the externalizing symptoms of aggressivity, conduct problems, and hyperactivity. Although this study did not find significant associations with the selected CGM metrics, research has found that adolescents with more externalizing behaviors such as aggression and antisocial conduct are associated with poorer glycemic control (Bryden et al., 2001). The discrepancy between this research study and others who have found significant associations with glycemic control and externalizing behaviors could be due to different methods of measuring glucose or how behavior was assessed. Aggressivity and other externalizing behaviors can be signs of glycemic levels that are suboptimal and should signal a need to check blood glucose levels (Haidar-Elatrache et al., 2018). McDonnell et al. (2007) researched the relationship between glucose and externalizing symptoms. The authors found that mean blood glucose levels were significantly associated with mean externalizing behaviors (McDonnell et al., 2007). McDonnell et al. (2007) also measured behavioral correlations to glycemic variation. Variation in average blood glucose levels explained 8.8% of the variance group mean of externalizing behaviors. Indeed, researchers have demonstrated that glycemic variability may be a stronger indicator of glucose control than even glucose averages (Wilmot et al., 2019). Given those findings, future research could examine CGM metrics that reflect glycemic variability beyond percent time in range to better understand the association of maintaining consistent glucose levels on behavior. For instance, the standard deviation (SD) of average glucose levels and the coefficient of variation, which is the SD proportional to the mean, reflect day-to-day differences. Another variability metric includes glycemic excursions, which reflect the number of times glucose levels fall above or below a specified target value (which may be target range). Although teachers may not see these in real-time, the CGM output will typically generate these variability metrics. The current study did not include these particular metrics as it would be more difficult for educators to have access to these data, and some must be computed over time. Nonetheless, if associations are found between these additional metrics of glycemic variability and teacher-reported behaviors, it would provide justification for school personnel to invest in students' diabetes management.

Research Question 2: Physical Activity and Teacher Reported Behaviors

The second hypothesis sought to determine the effects that physical activity had on student behavior, as rated by their teachers. Physical activity was measured through the Block Physical Activity Screener using kilocalories to estimate the energy expenditure for all activities during a week. In addition, the number of minutes spent in moderate and vigorous activity was also examined. Youth are recommended to engage in one hour of moderate to vigorous physical activity per day (Twisk, 2001). Forty-eight percent of this sample reported obtaining the recommended amount of physical activity, meaning over half the youth did not meet the criterion. Overall, there were no significant correlations between physical activity as measured by Kcal and teacher reported behaviors. The ADA (2020) noted that there is not strong enough evidence to delineate the type, timing, intensity, and duration of physical activity needed for optimal glycemic control. More research is needed in this area to form a better understanding of precisely how physical activity affects glycemic control and behaviors at school.

Research Question 3: Mediating Role of Glycemic Control in the Association Between Physical Activity and Teacher-Reported Behaviors

The third research question examined the mediational role that participant's glycemic control had on physical activity and behavior. Two models were run, one with the average glucose over a full week and teacher-reported depression and the other with average glucose levels during school and teacher-reported anxiety. Physical activity and CGM average glucose levels across the full week or during school (the mediators) were not significantly related. In both models, the total effect (effect of x on y, without m) of physical activity on teacher-reported depressive symptoms or anxiety was not statistically significant. Although the indirect effect of physical activity on depressive symptoms through average glucose levels across the full week did not reach significance, the mediator (average glucose levels across the full week) significantly predicted depressive symptoms. However, the mediator (average glucose during school hours) did not reach significance in predicting teacher-reported anxiety symptoms. These findings may have resulted from a number of factors such as relying on a self-reported physical activity screener not fully capturing actual physical activity (see below), the documented research that physical activity is not a contributing factor in diabetes disease control, or another unassessed variable as a factor.

Limitations

Sample

One limitation to this study was that the sample was derived from a larger study. Thus, participants were aware that they were enrolling in a study that involved participating in one of two types of sleep interventions and that they may be asked to change their sleep schedule. They were informed that data would be collected related to physical activity, diet, sleep, behaviors, and diabetes quality of life and management. It is possible those enrolled engaged in more or less physical activity than patients who did not participate. Regarding representation, nearly half of the participants identified as Latinx, reflecting the demographics of the community, with the other half identifying as White, non-Hispanic. This sample can make generalizing these results difficult. In the future, it would be beneficial to focus on recruitment strategies that diversify the sample. Coakley et al. (2012) highlight some strategies for increasing diversity through recruitment strategies such as clear communication that builds trust, raising awareness, involving surrounding communities, using the evolving technology to reach more participants, and collaborating across sectors.

Measurement

Physical activity was measured through a retrospective self-reported screening tool. The precision of this tool should be considered when interpreting the results and generalizability of this study. It is unclear if physical activity was truly not related to teacher-reported behaviors or if the screening tool was not robust enough to estimate actual physical activity levels that may have related to behaviors. In the future, research could confirm the reporting from the screener with other physical activity measurement tools. The use of accelerometer watches to examine participant activity levels could be helpful in corroborating the results of the Block Physical Activity Screener. Future studies could compare real-time physical activity with concurrent CGM levels or use physical activity as an intervention. For instance, a study in participants with T1DM diagnoses could be assigned to different exercise conditions and examine glucose levels.

Isolation of School Hours

The proximity of glucose to behavior is also a limitation of this study. Although glucose levels were narrowed down to the hours that participants spent at school throughout a week, times when teachers saw the students were not isolated. Thus, the responding teacher may have observed a student for only one class period in each day or not on a daily basis. For example, a high school student may have six classes per day, meaning that a teacher would only see that student for a short time period over the course of the school day. There were some instances of unavailability of teachers, especially when the participant was in a non-traditional school. Further, as the BASC-2 is an omnibus measure of multiple behaviors over a month period, behavior was rated over a more general period of time and responses most likely captured 'typical' behavior rather than behaviors in the exact moment of ratings in comparison to what their glucose was at that time. One way to address this limitation is to include behavioral observations as part of the study and randomized sampling of teacher-recorded behaviors using ecological momentary assessments. The trained observers and teachers should be blind to the students' glucose levels, but the times could be mapped onto CGM values for momentary assessments.

Continuous Glucose Monitor

This study used a criterion of having at least three days of glucose readings. Therefore, participants with less than two school days of CGM sensor readings were excluded, reducing the sample size further. Additionally, some participant data (n = 102 for full week; an additional 10 during school) showed gaps in the CGM sensor readings, and thus, skip patterns could reflect device failure.

Cross-Sectional Study Design

Although the present study was completed over the course of a week allowing for sampling of multiple days, the cross-sectional design between physical activity, glycemic regulation, and teacher-reported behaviors had limitations. Cross-sectional studies can infer association but not causation (Sedgwick, 2014). There are also greater chances for non-response bias, meaning that there may be a difference in groups who participated in the study versus those who did not (Sedgwick, 2014). Repeating cross-sectional studies can help mitigate these limitations (Sedgwick, 2014).

Future Directions

Given that the strongest CGM glycemic measures associated with behaviors were average glucose across the week and percent time in target range across the week, future research should study these metrics further. Future research is needed to track the correspondence of momentary changes in glucose levels with real-world behaviors in the classroom as well as examine changes in glycemic control and behaviors in response to medical management of diabetes, physical activity, and behavioral interventions. Further classroom observed behaviors could be compared to CGM levels concurrently at the precise time. If an association was found, this would provide parents and schools with information about why a child may be behaving differently. Such patterns could signal a need to check glycemic levels in order to maintain optimal diabetes management or suggest students with T1DM may benefit from an accommodation or temporary adjustment to mitigate the immediate impact of elevated glucose levels.

The Limitations section addressed some ways to improve research examining the association of physical activity and behaviors as well as the role that glucose plays in that relationship. However, additional research is needed to understand exactly how physical activity, which is recommended as a health habit for youth with T1DM, interacts with glycemic control (Rebesco et al., 2020). Research is beginning to implicate glycemic variability in health outcomes. Rebesco et al. (2020) sought to compare glycemic variability and physical activity levels. The authors found that glycemic variability did not significantly change based on the amount of exercise participants engaged in. In another study that utilized glycemic variability, the authors found that increased glycemic variability was associated with lower quality of life and negative moods (Penckofer et al., 2012). As CGM captures glucose levels as they fluctuate, these data can potentially help researchers understand associations with the variability in glycemic control over time.

Given this study did not shed light on the association between glycemic control and externalizing behaviors, school psychologists should consider alternate assessments to track how behavior changes correspond to glycemic control. Valdovinos and Weyand (2006) conducted a case study design in which four behaviors (aggression, self-injurious behavior, throwing objects, dropping to floor) were observed in 5-minute intervals and compared to mean blood glucose levels, as measured by blood glucose level checks 30 minutes prior to the observation period. The findings showed that the higher the mean blood glucose levels, the higher the rate of problem behavior. This association demonstrated the usefulness in measuring glucose to behavior in real-time. This participant used a blood glucose meter, checking glycemic levels twice during the observation period. The advent of the CGM measuring blood glucose levels continuously lends itself to innovative single subject research designs that would help support children's behavioral outcomes in school.

Practical Implications

Management of TIDM must be addressed at school, due to the significant hours that youth spend there (ADA, 2016). Educating school staff on diabetes management and the associations of poorer academic and mental health outcomes in this population could be beneficial since students spend much of their days at school. Staff with an understanding of what is necessary in managing T1DM at school may encourage students to check their blood glucose levels regularly. It is important to keep in mind that research has suggested that teachers may miss internalizing symptoms as students may experiences these inwardly. Thus, recognition of anxiety or depressive symptoms must stem from a stronger relationship with the student(s), students who are more articulate regarding their experiences, or particular behaviors that were more noticeable to teachers (Zee & Rudasill, 2021). Given that this study showed an association between glycemic control and internalizing behaviors, if teachers recognize students who display more anxious or depressive symptoms, school staff may have more of an understanding of reasons behind the behavior. If glucose levels are found to be outside of the target range, steps should be taken to correct blood glucose to remain at the optimal level. If students need the assistance of an adult, teaming with school nurses or health assistants may prove beneficial in supporting the student. If teachers have misunderstandings of diabetes, they may exclude students from certain activities (Litmanovitch et al., 2015).

These findings reflect the chronic dysregulation of glucose in the sample as a whole and support an association between average glucose levels and internalizing symptoms. With the noted findings of increased anxiety and depressive symptoms in youth with T1DM, school psychologists could be involved in interventions that improve coping skills in these students. Since the directional association between glycemic control and internalizing symptoms is still unclear, interventions that focus on proactive diabetes management as well as coping strategies would be beneficial for students (Luyckx et al., 2010).

Therefore, it is especially important to note that children with T1DM can be eligible for services through Section 504 of the Rehabilitation Act or Individual with Disabilities Education Act (IDEA, 2004). Although services through IDEA can be considered if T1DM is interfering with a student's education and specialized instruction is necessary, a Section 504 Plan can be put into place to ensure that the student has equal access to education. Students with diabetes are protected under Section 504. Explicitly, per the U.S. Department of Justice, Section 504 of the Rehabilitation Act states that "no qualified individual with a disability in the United States shall be excluded from, denied the benefits of, or be subjected to discrimination under any program or activity that receives federal financial assistance…" The regulations cover accommodations, program accessibility, applicable communication for individuals with hearing or vision disabilities, and accessible construction (U.S. Department of Justice, 2009). Examples include, but are not limited to, participation in all extracurricular activities, extra allowances for absences, and permission to eat snacks as needed (ADA, 2020).

Conclusion

In conclusion, despite research underscoring a higher prevalence of mental health and emotional difficulties in individuals with T1DM (Bernstein et al., 2013) and the Standards (ADA, 2020) recommending routine screening across a range of social-emotional and behavioral symptoms, most research has essentially ignored teachers as important informants to student behavioral functioning. It is important to incorporate teachers in research that involves youth because they are with students 6-8 hours per weekday and can play a role in improving outcomes for youth with T1DM. To fill this gap, this study sought to determine the direct contribution that glycemic control played in predicting teacher-reported behaviors as well as the mediating role of glycemic control in explaining the relations between physical activity and behaviors in school. Overall, certain glucose metrics shared a weak, but significant relation with internalizing behaviors, but did not relate to externalizing behaviors. The findings highlight that accounting for glucose as a continuum of measurement is more robust than discretely grouping participants into categories of hypoglycemia, in target range, and hyperglycemia, as well as holds more explanatory power in understanding behaviors than HbA1c. In this regard, average glucose levels across the full week measured via CGM had significant bivariate relations with multiple BASC-2 scales, suggesting that difficulties with disease management and behavioral functioning in school at least in part co-occur. Therefore, this study adds to the literature by demonstrating that glycemic control is related to students' internalizing symptoms, learning challenges, study habits, and attention.

Although average glucose levels during school significantly related to teacher-reported anxiety symptoms and overall internalizing symptoms, isolating the hours that students were in school did not add to the overall understanding of what behaviors teachers were observing in the classroom. Isolating just the school week glucose averages for the summative rating scales may not be necessary. Using the overall hours for the week showed the most potential for capturing the types of behaviors that teachers are observing in students with T1DM.

Although the current study's design did not demonstrate causation of glycemic control to behaviors, the results do underscore the need to consider that this is one factor influencing student's behaviors, or at least exacerbating challenges for which students may be more vulnerable. Nonetheless, the current study focused on the pathway of glycemic control to manifestation of behaviors, and as noted above, it is possible that youth with T1DM who struggle with behaviors have more difficulty managing their diabetes, which then leads to glycemic dysregulation. Thus, future research should incorporate direct measures of self-care behaviors (e.g., fingersticks, insulin administration compliance, etc.) to determine the association with disease management with teacher-reported behaviors. Youth with T1DM experience a higher risk for anxiety, which results in worse glycemic control and HbA1c levels, lower quality of life, increased chance of hospitalization, and higher levels of depression (Rechenberg, et al., 2017). Youth with T1DM who experience an increased risk of depression are at a greater risk of poorer glycemic control (Buchberger et al., 2016).

Central to the mission of school psychology is improving the instructional outcomes of students by removing barriers to education, which may include children's health and mental health problems (Power et al., 1999). School psychologists' knowledge of childhood development, mental health, and academics prepares them to understand and intervene with many of the issues that pediatric students face (Barraclough & Machek, 2010). Using these findings, school personnel can be instrumental in supporting students with T1DM by facilitating educational trainings for school staff, advocating for equal access to education, and providing interventions.

References

Addala, A., Maahs, D. M., Scheinker, D., Chertow, S., Leverenz, B., & Prahalad, P. (2020). Uninterrupted continuous glucose monitoring access is associated with a decrease in HbA1c in youth with type 1 diabetes and public insurance. *Pediatric Diabetes*, *21*(7), 1301-1309. https://doi.org/10.1111/pedi.13082

Agarwal, S., Kanapka, L. G., Raymond, J. K., Walker, A., Gerard-Gonzalez, A., Kruger, D., ... & Long, J. A. (2020). Racial-ethnic inequity in young adults with type 1 diabetes. *The Journal of Clinical Endocrinology & Metabolism*, *105*(8), e2960-e2969.

Ahmed, E. S., Monazea, E. M., Abdel-El Naser, A. E., & Kotb, S. A. (2016). Emotional, behavioral and social difficulties among children with type 1 diabetes mellitus. *International Journal of Advanced Nursing Studies*, *5*(2), 250.

Akbaş, S., Karabekiroğlu, K., Ŏzgen, T., Tasdemir, G., Karakurt, M., Şenses, A., ... & Aydin, M. (2009). Association between emotional and behavior problems and metabolic control in children and adolescents with Type 1 diabetes. *Journal of Endocrinological Investigation, 32*(4), 325-329. https://doi.org/10.1007/BF03345721

Albano, A. M., Chorpita, B. F., & Barlow, D.H. (2003). Childhood anxiety disorders. *Child Psychopathology, 2,* 279-329.

Åman, J., Skinner, T. C., De Beaufort, C. E., Swift, P. G., Aanstoot, H. J., Cameron, F., & Hvidoere Study Group on Childhood Diabetes. (2009). Associations between physical activity, sedentary behavior, and glycemic control in a large cohort of adolescents with type 1 diabetes: the Hvidoere study group on childhood diabetes. *Pediatric Diabetes*, *10*(4), 234-239. https://doi.org/10.1111/j.1399-5448.2008.00495.x

American Diabetes Association (2020). Standards of Medical Care in Diabetes-2020. *The Journal of Clinical and Applied Research and Education, 343* S1-S212.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: Author.

Amillategui, B., Calle, J. R., Alvarez, M. A., Cardiel, M. A., & Barrio, R. (2007). Identifying the special needs of children with type 1 diabetes in the school setting. An overview of parents' perceptions. *Diabetic Medicine*, *24*(10), 1073-1079. https://doi.org/10.1111/j.1464-5491.2007.02250.x

Amillategui, B., Mora, E., Calle, J. R., & Giralt, P. (2009). Special needs of children with type 1 diabetes at primary school: perceptions from parents, children, and teachers. *Pediatric Diabetes*, *10*(1), 67-73. https://doi.org/10.1111/j.1399-5448.2008.00457.x

Ani, C., Bazargan, M., Hindman, D., Bell, D., Farooq, M. A., Akhanjee, L., . . . Rodriguez, M. (2008). Depression symptomatology and diagnosis: discordance between patients and physicians in primary care settings. *BMC Family Practice*, *9*(1), 1. https://doi.org/10.1186/1471-2296-9-1

Bădescu, S. V., Tătaru, C., Kobylinska, L., Georgescu, E. L., Zahiu, D. M., Zăgrean, A. M., & Zăgrean, L. (2016). The association between diabetes mellitus and depression. *Journal of medicine and life*, *9*(2), 120.

Barraclough, C., & Machek, G. (2010). School psychologists' role concerning children with chronic illnesses in schools. *Journal of Applied School Psychology*, *26*(2), 132-148.

Battelino, T., Conget, I., Olsen, B., Schütz-Fuhrmann, I., Hommel, E., Hoogma, R., ... & SWITCH Study Group. (2012). The use and efficacy of continuous glucose monitoring in type 1 diabetes treated with insulin pump therapy: a randomized controlled trial. *Diabetologia*, *55*(12), 3155-3162. https://doi.org/10.1007/s00125-012-2708-9

Beck, R. W., Bergenstal, R. M., Cheng, P., Kollman, C., Carlson, A. L., Johnson, M. L., & Rodbard, D. (2019). The relationships between time in range, hyperglycemia metrics, and HbA1c. *Journal of diabetes science and technology*, *13*(4), 614-626. https://doi.org/10.1177/1932296818822496

Beraki, Å., Magnuson, A., Särnblad, S., Åman, J., & Samuelsson, U. (2014). Increase in physical activity is associated with lower HbA1c levels in children and adolescents with type 1 diabetes: results from a cross-sectional study based on the Swedish pediatric diabetes quality registry (SWEDIABKIDS). *Diabetes Research and Clinical Practice*, *105*(1), 119-125. https://doi.org/10.1016/j.diabres.2014.01.029

Bernstein, C. M., Stockwell, M. S., Gallagher, M. P., Rosenthal, S. L., & Soren, K. (2013). Mental health issues in adolescents and young adults with type 1 diabetes: prevalence and impact on glycemic control. *Clinical pediatrics*, *52*(1), 10-15.

Biddle, S. J., & Asare, M. (2011). Physical activity and mental health in children and adolescents: a review of reviews. *British Journal of Sports Medicine*, *45*(11), 886–895. https://doi.org/10.1136/bjsports-2011-090185

Block, G., Jensen, C. D., Block, T. J., Norris, J., Dalvi, T. B., & Fung, E. B. (2009). The work and home activities questionnaire: energy expenditure estimates and association with percent body fat. *Journal of Physical Activity and Health*, *6*(s1), S61-S69. https://doi.org/10.1123/jpah.6.s1.s61

Brenes, G. A., Penninx, B. W., Judd, P. H., Rockwell, E., Sewell, D. D., & Wetherell, J. L. (2008). Anxiety, depression and disability across the lifespan. *Aging and Mental Health*, *12*(1), 158-163.

Bryden, K. S., Peveler, R. C., Stein, A., Neil, A., Mayou, R. A., & Dunger, D. B. (2001). Clinical and psychological course of diabetes from adolescence to young adulthood: a longitudinal cohort study. *Diabetes care*, *24*(9), 1536-1540.

Buchberger, B., Huppertz, H., Krabbe, L., Lux, B., Mattivi, J. T., & Siafarikas, A. (2016). Symptoms of depression and anxiety in youth with type 1 diabetes: a systematic review and meta-analysis. *Psychoneuroendocrinology*, *70*, 70-84. https://doi.org/10.1016/j.psyneuen.2016.04.019

Calfas, K. J., & Taylor, W. C. (1994). Effects of physical activity on psychological variables in adolescents. *Pediatric Exercise Science*, *6*(4), 406-423. https://doi.org/10.1123/pes.6.4.406

Cavanaugh, S. V. A., Furlanetto, L. M., Creech, S. D., & Powell, L. H. (2001). Medical illness, past depression, and present depression: a predictive triad for in-hospital mortality. *American Journal of Psychiatry*, *158*(1), 43-48. https://doi.org/10.1176/appi.ajp.158.1.43

Centers for Disease Control and Prevention. (2020). National diabetes statistics report: estimates of diabetes and its burden in the United States, 2014. *Atlanta, GA: US Department of Health and Human Services*, *2014*.

Cohen D. M., Lumley M. A., Naar-King, S., Partridge, T., and Cakan, N. (2004). Child behavior problems and family functioning as predictors of adherence and glycemic control in economically disadvantaged children with type 1 diabetes: a prospective study. *Journal of Pediatric Psychology, 29(3)*, 171-184. https://doi.org/10.1093/jpepsy/jsh019

Collett, B. R., Ohan, J. L., & Myers, K. M. (2003). Ten-year review of rating scales. V: scales assessing attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, *42*(9), 1015-1037. https://doi.org/10.1097/01.CHI.0000070245.24125.B6

Cooke, D. W., & Plotnick, L. (2008). Type 1 diabetes mellitus in pediatrics. *Pediatrics In Review*, *29*(11), 374-84. https://doi.org/10.1542/pir.29-11-374

Cuenca-García, M., Jago, R., Shield, J. P. H., & Burren, C. P. (2012). How does physical activity and fitness influence glycemic control in young people with type 1 diabetes?. *Diabetic Medicine*, *29*(10), e369-e376. https://doi.org/10.1111/j.1464-5491.2012.03740.x

Dabelea D. The accelerating epidemic of childhood diabetes. *Lancet* 2009; 373: 1999-2000. https://doi.org/10.1016/S0140-6736(09)60874-6

Daneman, D. (2006). Type 1 Diabetes. *The Lancet, 367(9513)*, 847-858. https://doi.org/10.1016/S0140-6736(06)68341-4

Donenberg, G., & Baker, B. L. (1993). The impact of young children with externalizing behaviors on their families. *Journal of abnormal child psychology*, *21*(2), 179-198.

de Zeeuw, E. L., van Beijsterveldt, C. E., Ehli, E. A., de Geus, E. J., & Boomsma, D. I. (2017). Attention deficit hyperactivity disorder symptoms and low educational achievement: evidence supporting a causal hypothesis. *Behavior Genetics*, *47*(3), 278-289. https://doi.org/10.1007/s10519-017-9836- 4

Deiss, D., Bolinder, J., Riveline, J. P., Battelino, T., Bosi, E., Tubiana-Rufi, N., . . . & Phillip, M. (2006). Improved glycemic control in poorly controlled patients with type 1 diabetes using real-time continuous glucose monitoring. *Diabetes Care*, *29*(12), 2730-2732. https://doi.org/10.2337/dc06-1134

Ducat, L., Philipson, L. H., & Anderson, B. J. (2014). The mental health comorbidities of diabetes. *Jama*, *312*(7), 691-692. https://doi.org/10.1001/jama.2014.8040

Dunger, D. B., Sperling, M. A., Acerini, C. L., Bohn, D. J., Daneman, D., Danne, T. P., . . . & Savage, M. O. (2004). European Society for Pediatric Endocrinology/Lawson Wilkins Pediatric Endocrine Society consensus statement on diabetic ketoacidosis in children and adolescents. *Pediatrics*, *113*(2), e133-e140. https://doi.org/10.1542/peds.113.2.e133

Frye, S. S., Perfect, M. M., & Silva, G. E. (2019). Diabetes management mediates the association between sleep duration and glycemic control in youth with type 1 diabetes mellitus. *Sleep Medicine*, *60*, 132-138. https://doi.org/10.1016/j.sleep.2019.01.043

Gallegos-Macias, A. R., Macias, S. R., Kaufman, E., Skipper, B., & Kalishman, N. (2003). Relationship between glycemic control, ethnicity and socioeconomic status in Hispanic and white non-Hispanic youths with type 1 diabetes mellitus. *Pediatric diabetes*, *4*(1), 19-23.

Galler, A., Lindau, M., Ernert, A., Thalemann, R., & Raile, K. (2011). Associations between media consumption habits, physical activity, socioeconomic status, and glycemic control in children, adolescents, and young adults with type 1 diabetes. Diabetes care, 34(11), 2356-2359.

Gendelman, N., Snell-Bergeon, J. K., McFann, K., Kinney, G., Wadwa, R. P., Bishop, F., . . . & Maahs, D. M. (2009). Prevalence and correlates of depression in individuals with and without type 1 diabetes. *Diabetes Care*, *32*(4), 575-579. https://doi.org/10.2337/dc08-1835

Goldstein, E., Topitzes, J., Brown, R. L., & Barrett, B. (2020). Mediational pathways of meditation and exercise on mental health and perceived stress: A randomized controlled trial. *Journal of health psychology*, *25*(12), 1816-1830.

Gonder-Frederick, L. A., Zrebiec, J. F., Bauchowitz, A. U., Ritterband, L., Magee, J. C., Cox, D. J., & Clarke, W. L. (2009). Cognitive function is disrupted by both hypo-and hyperglycemia in school-aged children with type 1 diabetes: a field study. *Diabetes Care*, *32*(6), 1001-1006. https://doi.org/10.2337/dc08-1722

Gross, T. M., & Mastrototaro, J. J. (2000). Efficacy and reliability of the continuous glucose monitoring system. *Diabetes Technology & Therapeutics*, *2*(1), 19-26. https://doi.org/10.1089/15209150050214087

Haidar-Elatrache, S., Wolf, M., Fabie, N. A. V., & Sahai, S. (2018). Approach to children with aggressive behavior for general pediatricians and hospitalists: part 1—epidemiology and etiology. *Pediatric annals*, *47*(10), e402-e407

Harkness, E., Macdonald, W., Valderas, J., Coventry, P., Gask, L., & Bower, P. (2010). Identifying psychosocial interventions that improve both physical and mental health in patients with diabetes: a systematic review and meta-analysis. *Diabetes Care*, *33*(4), 926-930. https://doi.org/10.2337/dc09-1519

Hassan, K., Loar, R., Anderson, B. J., & Heptulla, R. A. (2006). The role of socioeconomic status, depression, quality of life, and glycemic control in type 1 diabetes mellitus. *The Journal of pediatrics*, *149*(4), 526-531.

Hatoum, A. S., Rhee, S. H., Corley, R. P., Hewitt, J. K., & Friedman, N. P. (2018). Etiology of stability and growth of internalizing and externalizing behavior problems across childhood and adolescence. *Behavior Genetics*, *48*(4), 298-314. https://doi.org/10.1007/s10519-018-9900-8

Hayes, A. F. (2012). PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling.

Hayes-Bohn, R., Neumark-Sztainer, D., Mellin, A., & Patterson, J. (2004). Adolescent and parent assessments of diabetes mellitus management at school. *Journal of School Health*, *74*(5), 166-169.

Healy, G. N., Dunstan, D. W., Salmon, J., Cerin, E., Shaw, J. E., Zimmet, P. Z., & Owen, N. (2007). Objectively measured light-intensity physical activity is independently associated with 2-h plasma glucose. *Diabetes care*, *30*(6), 1384-1389.

Herzer, M., Hood, K. K. (2010). Anxiety Symptoms in Adolescents with Type 1 Diabetes: Association with Blood Glucose Monitoring and Glycemic Control. *Journal of Pediatric Psychology*, 35(*4*), 415–425. https://doi.org/10.1093/jpepsy/jsp063

Hilgard, D., Konrad, K., Meusers, M., Bartus, B., Otto, K. P., Lepler, R., . . . & German/Austrian DPV Study Group, the Working Group on Psychiatric, Psychotherapeutic Psychological Aspects of Paediatric Diabetology (PPAG eV) and the BMBF Competence Network Diabetes, Germany. (2017). Comorbidity of attention deficit hyperactivity disorder and type 1 diabetes in children and adolescents: Analysis based on the multicentre DPV registry. *Pediatric Diabetes*, *18*(8), 706-713. https://doi.org/10.1111/pedi.12431

Hilliard, M. E., Yi-Frazier, J. P., Hessler, D., Butler, A. M., Anderson, B. J., & Jaser, S. (2016). Stress and A1c Among People with Diabetes Across the Lifespan. *Current diabetes reports*, *16*(8), 67. https://doi.org/10.1007/s11892-016-0761-3

Hood, K. K., Huestis, S., Maher, A., Butler, D., Volkening, L., & Laffel, L. M. (2006). Depressive symptoms in children and adolescents with type 1 diabetes: association with diabetes-specific characteristics. *Diabetes care*, *29*(6), 1389-1389.

Individuals with Disabilities Education Act, 20 U.S.C. § 1400 (2004).

Izquierdo, R., Morin, P. C., Bratt, K., Moreau, Z., Meyer, S., Ploutz-Snyder, R., Wade, M., & Weinstock, R. S. (2009). School-centered telemedicine for children with type 1 diabetes mellitus. *The Journal of Pediatrics*, *155*(3), 374-379. https://doi.org/10.1016/j.jpeds.2009.03.014

Jackson, C. C., Albanese-O'Neill, A., Butler, K. L., Chiang, J. L., Deeb, L. C., Hathaway, K., . . . & Siminerio, L. M. (2015). Diabetes care in the school setting: a position statement of the American Diabetes Association. *Diabetes Care*, *38*(10), 1958-1963. https://doi.org/10.2337/dc15-1418

Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(1), 40. https://doi.org/10.1186/1479-5868-7-40

Katon, W. J., Von Korff, M., Lin, E. H., Simon, G., Ludman, E., Russo, J., . . . & Bush, T. (2004). The pathways study: A randomized trial of collaborative care in patients with diabetes and depression. *Archives of General Psychiatry*, *61*(10), 1042-1049. https://doi.org/10.1001/archpsyc.61.10.104

Kaufman FR, Gibson LC, Halvorson M, Carpenter S, Fisher LK, Pitukcheewanont P. A pilot study of the continuous glucose monitoring system: clinical decisions and glycemic control after its use in pediatric type 1 diabetic subjects. *Diabetes Care*. 2001;24(12):2030-2034. https://doi.org/10.2337/diacare.24.12.2030

Kazdin, A. E. (1997). Practitioner review: Psychosocial treatments for conduct disorder in children. *Journal of Child Psychology and Psychiatry*, *38*(2), 161-178. https://doi.org/10.1111/j.1469-7610.1997.tb01851.x

Kendall, P. C., Compton, S. N., Walkup, J. T., Birmaher, B., Albano, A. M., Sherrill, J., . . . & Keeton, C. (2010). Clinical characteristics of anxiety disordered youth. *Journal of Anxiety Disorders*, *24*(3), 360-365. https://doi.org/10.1016/j.janxdis.2010.01.009

Knight, M. F., & Perfect, M. M. (2019). Glycemic control influences on academic performance in youth with Type 1 diabetes. *School Psychology*, *34*(6), 646. https://doi.org/10.1037/spq0000320

Lau, C., Stewart, S. L., Saklofske, D. H., & Hirdes, J. (2019). Scale development and psychometric properties of internalizing symptoms: the interRAI Child and Youth Mental Health internalizing subscale. *Psychiatry research*, *278*, 235-241. https://doi.org/10.1016/j.psychres.2019.06.013

Leclair, E., De Kerdanet, M., Riddell, M., & Heyman, E. (2013). Type 1 diabetes and physical activity in children and adolescents. *J Diabetes Metab*, *10*(004). https://doi.org/10.4172/2155-6156.S10-004

Lehmkuhl, H., & Nabors, L. (2008). Children with diabetes: Satisfaction with school support, illness perceptions and HbA1c levels. *Journal of Developmental and Physical Disabilities*, *20*(2), 101. https://doi.org/10.1007/s10882-007-9082-4

Leonard, B. J., Jang, Y. P., Savik, K., Plumbo, P. M., & Christensen, R. (2002). Psychosocial factors associated with levels of metabolic control in youth with type 1 diabetes. *Journal of pediatric nursing*, *17*(1), 28-37. https://doi.org/10.1053/jpdn.2002.30931

Lipman, T. H., & Hawkes, C. P. (2021). Racial and socioeconomic disparities in pediatric type 1 diabetes: Time for a paradigm shift in approach. *Diabetes Care*, *44*(1), 14-16.

Litmanovitch, E., Geva, R., & Rachmiel, M. (2015). Short and long term neuro-behavioral alterations in type 1 diabetes mellitus pediatric population. *World journal of diabetes*, *6*(2), 259.

Lloyd, C. E., Pambianco, G., & Orchard, T. J. (2010). Does diabetes-related distress explain the presence of depressive symptoms and/or poor self-care in individuals with Type 1 diabetes?. *Diabetic Medicine*, *27*(2), 234-237. https://doi.org/10.1111/j.1464-5491.2009.02896.x

Lobitz, W., Brammell, H., Stoll, S., & Niccoli, A. (1983). Physical exercise and anxiety management training for cardiac stress management in a nonpatient population. *Journal of Cardiac Rehabilitation*, *3*(10), 683-688.

Long, A. E., & Bingley, P. J. (2009). The epidemiology of childhood diabetes. *Pediatrics and Child Health*, *19*(7), 304-308. https://doi.org/10.1016/j.paed.2013.01.001

Lorant V, Deliège D, Eaton W, Robert A, Philippot P, Ansseau M. Socioeconomic inequalities in depression: a meta-analysis. Am J Epidemiol. 2003 Jan 15;157(2):98-112. https://doi.org/10.1093/aje/kwf182. PMID: 12522017

Luyckx, K., Seiffge-Krenke, I., & Hampson, S. E. (2010). Glycemic control, coping, and internalizing and externalizing symptoms in adolescents with type 1 diabetes: A cross-lagged longitudinal approach. *Diabetes Care*, *33*(7), 1424-1429.

Lyoo, I. K., Yoon, S., Jacobson, A. M., Hwang, J., Musen, G., Kim, J. E., ... & Renshaw, P. F. (2012). Prefrontal cortical deficits in type 1 diabetes mellitus: brain correlates of comorbid depression. *Archives of general psychiatry*, *69*(12), 1267-1276.

Maahs, D. M., West, N. A., Lawrence, J. M., & Mayer-Davis, E. J. (2010). Epidemiology of type 1 diabetes. *Endocrinology and Metabolism Clinics*, *39*(3), 481-497. https://doi.org/10.1016/j.ecl.2010.05.011

Maas-van Schaaijk, N. M., Roeleveld-Versteegh, A. B., Odink, R. R., & van Baar, A. L. (2013). Behavioral problems and depressive symptoms in adolescents with type 1 diabetes mellitus: self and parent reports. *Diabetes Mellitus-Insights and Perspectives*, 47-58.

Marks, A., Wilson, V., & Crisp, J. (2013). The management of type 1 diabetes in primary school: review of the literature. *Issues In Comprehensive Pediatric Nursing*, *36*(1-2), 98-119. doi:10.3109/01460862.2013.782079

Mauras, N., Beck, R., Xing, D., Ruedy, K., Buckingham, B., Tansey, M., . . . & Diabetes Research in Children Network (DirecNet) Study Group. (2012). A randomized clinical trial to assess the efficacy and safety of real-time continuous glucose monitoring in the management of type 1 diabetes in young children aged 4 to< 10 years. *Diabetes Care*, *35*(2), 204-210. https://doi.org/10.2337/dc11-1746

McDonnell, C. M., Northam, E. A., Donath, S. M., Werther, G. A., & Cameron, F. J. (2007). Hyperglycemia and externalizing behavior in children with type 1 diabetes. *Diabetes Care*, *30*(9), 2211-2215. https://doi.org/10.2337/dc07-0328

McGrady, M. E., Peugh, J. L., & Hood, K. K. (2014). Illness representations predict adherence in adolescents and young adults with type 1 diabetes. *Psychology & Health*, *29*(9), 985-998. https://doi.org/10.1080/08870446.2014.899361

McIntyre, R. S., Kenna, H. A., Nguyen, H. T., Law, C. W., Sultan, F., Woldeyohannes, H. O., ... & Rasgon, N. L. (2010). Brain volume abnormalities and neurocognitive deficits in diabetes mellitus: points of pathophysiological commonality with mood disorders?. *Advances in therapy*, *27*(2), 63-80.

Medtronic (2015). iPro2 User Guide. Retrieved June 5, 2019 from https://www.medtronicdiabetes.com/sites/default/files/library/download-library/user-guides/iPro2_User_Guide-en-US.pdf

Melchior, M., Chastang, J. F., Walburg, V., Arseneault, L., Galéra, C., & Fombonne, E. (2010). Family income and youths' symptoms of depression and anxiety: a longitudinal study of the French GAZEL Youth cohort. *Depression and Anxiety*, *27*(12), 1095-1103.

Menard, S. (2004). Six approaches to calculating standardized logistical regression coefficients. *The American Statistician, 58*(3), 218-223.

Michaliszyn, S. F., & Faulkner, M. S. (2010). Physical activity and sedentary behavior in adolescents with type 1 diabetes. *Research In Nursing & Health*, *33*(5), 441-449. https://doi:10.1002/nur.20393

Mutlu, E. K., Mutlu, C., Taskiran, H., & Ozgen, I. T. (2015). Association of physical activity level with depression, anxiety, and quality of life in children with type 1 diabetes mellitus. *Journal of Pediatric Endocrinology and Metabolism*, *28*(11-12), 1273-1278. https://doi.org/10.1515/jpem-2015-0082

Nabors, L., Troillett, A., Nash, T., & Masiulis, B. (2005). School nurse perceptions of barriers and supports for children with diabetes. *Journal of School Health, 75*(4), 119-124.

Nelson, A. (2002). Unequal treatment: confronting racial and ethnic disparities in health care. *Journal of the national medical association*, *94*(8), 666.

NGSP Web Site. (n.d.). Retrieved July 19, 2020, from http://www.ngsp.org/

Nock, M. K., Kazdin, A. E., Hiripi, E., & Kessler, R. C. (2006). Prevalence, subtypes, and correlates of DSM-IV conduct disorder in the National Comorbidity Survey Replication. *Psychological Medicine*, *36*(5), 699-710. https://doi.org/10.1017/S0033291706007082

Northam, E. A., Matthews, L. K., Anderson, P. J., Cameron, F. J., & Werther, G. A. (2005). Psychiatric morbidity and health outcome in Type 1 diabetes–perspectives from a prospective longitudinal study. *Diabetic Medicine*, *22*(2), 152-157. https://doi.org/10.1111/j.1464-5491.2004.01370.x

Northam, E. A., Todd, S., & Cameron, F. J. (2006). Interventions to promote optimal health outcomes in children with Type 1 diabetes—are they effective?. *Diabetic Medicine*, *23*(2), 113-121.

Nylander, C., Lindström, K., Khalifa, N., & Fernell, E. (2018). Previously undiagnosed attention-deficit/hyperactivity disorder associated with poor metabolic control in adolescents with type 1 diabetes. *Pediatric diabetes*, *19*(4), 816-822. https://doi.org/10.1111/pedi.12651

Orpinas, P., & Frankowski, R. (2001). The Aggression Scale: a self-report measure of aggressive behavior for young adolescents. *The Journal of Early Adolescence*, *21*(1), 50-67. https://doi.org/10.1177/0272431601021001003

Osborne, J. W., & Waters, E. (2002). Four assumptions of multiple regression that researchers should always test. *Practical assessment, research, and evaluation*, *8*(1), 2. https://doi.org/10.7275/r222-hv23

Paluska, S. A., & Schwenk, T. L. (2000). Physical activity and mental health. *Sports Medicine*, *29*(3), 167-180. https://doi.org/10.2165/00007256-200029030-00003

Pansier, B., & Schulz, P. J. (2015). School-based diabetes interventions and their outcomes: a systematic literature review. *Journal of Public Health Research*, *4*(1). https://doi.org/10.4081/jphr.2015.467

Parent, K. B., Wodrich, D. L., & Hasan, K. S. (2009). Type 1 diabetes mellitus and school: a comparison of patients and healthy siblings. *Pediatric diabetes*, *10*(8), 554-562.

Paris, C. A., Imperatore, G., Klingensmith, G., Petitti, D., Rodriguez, B., Anderson, A. M., . . . & Pihoker, C. (2009). Predictors of insulin regimens and impact on outcomes in youth with type 1 diabetes: the SEARCH for Diabetes in Youth study. *The Journal of Pediatrics*, *155*(2), 183-189. https://doi.org//10.1016/j.jpeds.2009.01.063

Parker, J., Martyn-St James, M., Green, M. A., Lewis-Hanna, L., Dias, R., Morris, B., . . . & Chalhoub, N. (2016). Physical activity for improving the symptoms of attention deficit hyperactivity disorder in children and adolescents. *Cochrane Database of Systematic Reviews*, (3). https://doi.org/10.1002/14651858.CD012107

Patton, S. R., Williams, L. B., Eder, S. J., Crawford, M. J., Dolan, L., & Powers, S. W. (2011). Use of continuous glucose monitoring in young children with type 1 diabetes: implications for behavioral research. *Pediatric diabetes*, *12*(1), 18-24.

Peluso, M. A., & Guerra de Andrade, L. H. (2005). Physical activity and mental health: the association between exercise and mood. *Clinics*, *60*(1), 61–70. https://doi.org/10.1590/s1807-59322005000100012

Penckofer, S., Quinn, L., Byrn, M., Ferrans, C., Miller, M., & Strange, P. (2012). Does glycemic variability impact mood and quality of life?. *Diabetes technology & therapeutics*, *14*(4), 303-310.

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current opinion in psychiatry*, *18*(2), 189-193.

Peralta, G. P., Forns, J., de la Hera, M. G., González, L., Guxens, M., López-Vicente, M., . . . & Garcia-Aymerich, J. (2018). Sleeping, TV, cognitively stimulating activities, physical activity, and attention-deficit hyperactivity disorder symptom incidence in children: a prospective study. *Journal of Developmental & Behavioral Pediatrics*, *39*(3), 192-199. https://doi.org/10.1097/DBP.0000000000000539

Perfect, M. M., Beebe, D. W., Levine-Donnerstein, D., Frye, S. S., Bluez, G. P., & Quan, S. F. (2016). The development of a clinically relevant sleep modification protocol for youth with type 1 diabetes. *Clinical Practice in Pediatric Psychology*, *4*(2), 227. https://doi.org/10.1037/cpp0000145

Perfect, M. M., Levine-Donnerstein, D., Swartz, N. E., Wheeler, L. E., & Amaya, G. M. (2011). Adolescents with diabetes and their parents' perceptions of mental health screening, assessment, and feedback. *Administration and Policy in Mental Health and Mental Health Services Research*, *38*(3), 181-192. https://doi.org/10.1007/s10488-010-0312-1

Petitti, D. B., Klingensmith, G. J., Bell, R. A., Andrews, J. S., Dabelea, D., Imperatore, G., ... & SEARCH for Diabetes in Youth Study Group. (2009). Glycemic control in youth with diabetes: the SEARCH for diabetes in Youth Study. *The Journal of pediatrics*, *155*(5), 668-672.

Pettitt, D. J., Talton, J., Dabelea, D., Divers, J., Imperatore, G., Lawrence, J. M., . . . & Saydah, S. H. (2014). Prevalence of diabetes in US youth in 2009: the SEARCH for diabetes in youth study. *Diabetes care*, *37*(2), 402-408. https://doi.org/10.2337/dc13-1838

Pinelli, L., Zaffani, S., Cappa, M., Carboniero, V., Cerutti, F., Cherubini, V., ... & Vanelli, M. (2011). The ALBA project: an evaluation of needs, management, fears of Italian young patients with type 1 diabetes in a school setting and an evaluation of parents' and teachers' perceptions. *Pediatric Diabetes*, *12*(5), 485-493. https://doi.org/10.1111/j.1399-5448.2010.00722.x

Quesada, D., Ahmed, N. U., Fennie, K. P., Gollub, E. L., & Ibrahimou, B. (2018). A review: associations between attention-deficit/hyperactivity disorder, physical activity, medication use, eating behaviors and obesity in children and adolescents. *Archives of Psychiatric Nursing*, *32*(3), 495-504. https://doi.org/10.1016/j.apnu.2018.01.006

Quirk, H., Blake, H., Tennyson, R., Randell, T. L., & Glazebrook, C. (2014). Physical activity interventions in children and young people with type 1 diabetes mellitus: a systematic review with meta-analysis. *Diabetic Medicine*, *31*(10), 1163-1173. https://doi:10.1111/dme.12531

Rebesco, D. B., França, S. N., Lima, V. A. D., Leite, N., Smouter, L., Souza, W. C. D., ... & Mascarenhas, L. P. G. (2020). Different amounts of moderate to vigorous physical activity and change in glycemic variability in adolescents with type 1 diabetes: is there dose-response relationship?. *Archives of endocrinology and metabolism*, *64*, 312-318.

Rechenberg, K., Whittemore, R., & Grey, M. (2017). Anxiety in youth with type 1 diabetes. *Journal of Pediatric Nursing*, *32*, 64-71. https://doi.org/10.1016/j.pedn.2016.08.007

Rewers, A., Chase, H. P., Mackenzie, T., Walravens, P., Roback, M., Rewers, M., . . . & Klingensmith, G. (2002). Predictors of acute complications in children with type 1 diabetes. *Jama*, *287*(19), 2511-2518. doi:10.1001/jama.287.19.2511

Rewers, A., Klingensmith, G., Davis, C., Petitti, D. B., Pihoker, C., Rodriguez, B., Schwartz, I. D., Imperatore, G., Williams, D., Dolan, L. M., &Dabelea, D. (2008). Presence of diabetic ketoacidosis at diagnosis of diabetes mellitus in youth: the Search for Diabetes in Youth Study. *Pediatrics*, *121*(5), e1258-e1266. https://doi.org/10.1542/peds.2007-1105

Reynolds, C. R. & Kamphaus, R. W. (2004). BASC-2: Behavior Assessment System for Children: Second Edition. Minneapolis, MN: Pearson.

Rice, W. R. (1989). Analyzing tables of statistical tests. *Evolution*, *43*(1), 223-225.

Schmidt, C. B., Potter van Loon, B. J., Torensma, B., Snoek, F. J., & Honig, A. (2017). Ethnic minorities with diabetes differ in depressive and anxiety symptoms and diabetes-distress. *Journal of diabetes research*, *2017*.

SEARCH for Diabetes in Youth Study Group. (2006). The burden of diabetes mellitus among US youth: prevalence estimates from the SEARCH for Diabetes in Youth Study. *Pediatrics*, *118*(4), 1510-1518. https://doi.org/10.1542/peds.2006-0690

Secrest, A. M., Costacou, T., Gutelius, B., Miller, R. G., Songer, T. J., & Orchard, T. J. (2011). Associations between socioeconomic status and major complications in type 1 diabetes: the Pittsburgh epidemiology of diabetes complication (EDC) Study. *Annals of epidemiology*, *21*(5), 374-381.

Sedgwick, P. (2014). Cross sectional studies: advantages and disadvantages. *Bmj*, *348*.

Sharma, M. K., & Marimuthu, P. (2014). Prevalence and psychosocial factors of aggression among youth. *Indian journal of psychological medicine*, *36*(1), 48-53.

Ströhle, A. (2009). Physical activity, exercise, depression and anxiety disorders. *Journal of Neural Transmission*, *116*(6), 777. https://doi.org/10.1007/s00702-008-0092-x

Strong, W. B., Malina, R. M., Blimkie, C. J., Daniels, S. R., Dishman, R. K., Gutin, B., . . . & Rowland, T. (2005). Evidence based physical activity for school-age youth. *The Journal of Pediatrics*, *146*(6), 732-737. https://doi.org/10.1016/j.jpeds.2005.01.055.

Sukhodolsky, D. G., Smith, S. D., McCauley, S. A., Ibrahim, K., & Piasecka, J. B. (2016). Behavioral interventions for anger, irritability, and aggression in children and adolescents. *Journal of Child and Adolescent Psychopharmacology*, *26*(1), 58-64. https://doi.org/10.1089/cap.2015.0120

Trivedi, M. H. (2009). Tools and strategies for ongoing assessment of depression: a measurement-based approach to remission. *The Journal of Clinical Psychiatry*, *70*, 26-31. https://doi.org/10.4088/JCP.8133su1c.04

Twisk, J. W. (2001). Physical activity guidelines for children and adolescents. *Sports medicine*, *31*(8), 617-627.

Valdovinos, M. G., & Weyand, D. (2006). Blood glucose levels and problem behavior. *Research in developmental disabilities*, *27*(2), 227–231. https://doi.org/10.1016/j.ridd.2005.02.002

Van Duinkerken, E., Snoek, F. J., & De Wit, M. (2020). The cognitive and psychological effects of living with type 1 diabetes: a narrative review. *Diabetic Medicine*, *37*(4), 555-563.

Vanstone, M., Rewegan, A., Brundisini, F., Dejean, D., & Giacomini, M. (2015). Patient perspectives on quality of life with uncontrolled type 1 diabetes mellitus: a systematic review and qualitative meta-synthesis. *Ontario health technology assessment series*, *15*(17), 1.

Vinker-Shuster, M., Golan-Cohen, A., Merhasin, I., & Merzon, E. (2019). Attention-deficit hyperactivity disorder in pediatric patients with type 1 diabetes mellitus: clinical outcomes and diabetes control. *Journal of Developmental & Behavioral Pediatrics*, *40*(5), 330-334. https://doi.org/10.1097/DBP.0000000000000670

Wade, L., Smith, J. J., Duncan, M. J., & Lubans, D. R. (2018). Mediators of aggression in a school-based physical activity intervention for low-income adolescent boys. *Mental Health and Physical Activity*, *14*, 39-46. https://doi.org/10.1016/j.mhpa.2017.12.006

Wagner, J., Heapy, A., James, A., & Abbott, G. (2006). Brief report: glycemic control, quality of life, and school experiences among students with diabetes. *Journal of Pediatric Psychology*, *31*(8), 764-769. https://doi:10.1093/jpepsy/jsj082

Wilmot, E. G., Choudhary, P., Leelarathna, L., & Baxter, M. (2019). Glycaemic variability: The under-recognized therapeutic target in type 1 diabetes care. Diabetes, obesity & metabolism, 21(12), 2599–2608. https://doi.org/10.1111/dom.13842

Wyckoff, L., Hanchon, T., & Gregg, S. R. (2015). Psychological, behavioral, and educational considerations for children with classified disabilities and diabetes within the school setting. *Psychology in the Schools*, *52*(7), 672-682. doi:10.1002/pits.21848

Yazar, A., Akın, F., Akça, Ö. F., Eklioğlu, B. S., Türe, E., Coşkun, F., & Atabek, M. E. (2019). The effect of attention deficit/hyperactivity disorder and other psychiatric disorders on the treatment of pediatric diabetes mellitus. *Pediatric Diabetes*, *20*(3), 345-352. https://doi.org/10.1111/pedi.12819

You, W. P., & Henneberg, M. (2016). Type 1 diabetes prevalence increasing globally and regionally: the role of natural selection and life expectancy at birth. *BMJ Open Diabetes Research and Care*, *4*(1). https://doi.org/10.1136/bmjdrc-2015-000161

Yu, C. C. W., Chan, S., Cheng, F., Sung, R. Y. T., & Hau, K. T. (2006). Are physical activity and academic performance compatible? Academic achievement, conduct, physical activity and self-esteem of Hong Kong Chinese primary school children. *Educational Studies*, *32*(4), 331-341. https://doi.org/10.1080/03055690600850016

Zee, M., & Rudasill, K. M. (2021). Catching sight of children with internalizing symptoms in upper elementary classrooms. *Journal of School Psychology*, *87*, 1-17.

Zheng, X. P., & Chen, S. H. (2013). Psycho-behavioral changes in children with type 1 diabetes mellitus. *World Journal of Pediatrics*, *9*(3), 261-265. https://doi.org/10.1007/s12519-013-0428-y