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Decreasing Hyperglycemia and Diabetic Ketoacidosis in Adolescents on the Insulin Pump: A Quality Improvement Project

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TABLE OF CONTENTS

Abstract

Background: The rate of hyperglycemia in adolescents with type 1 diabetes mellitus (T1DM) who use insulin pump therapy is three times higher than in those using multi-dose insulin. Current literature suggests that the causes of the increased hyperglycemia rate are insufficient patient education, missed insulin boluses for meals/snacks, pump malfunction, psychological effects, pubertal physiological changes, and adolescents' risky behavior.

Purpose: This quality improvement project aimed to reduce the rate of hyperglycemia and diabetic ketoacidosis in adolescents age 12–18 with T1DM on insulin pump therapy through evidence-based interventions.

Methods: Participants were recruited from four western Massachusetts public schools. Innovative diabetes self-care education and peer group support were used. Educational sessions and peer group knowledge discussions occurred once a week from January 10, 2017 to March 14, 2017.

Results: Findings indicated that the evidence-based educational program was effective in improving self-care skills in adolescents with T1DM on the insulin pump. The outcome showed that when knowledge of self-care management improved, the complications of TIDM such as hyperglycemia and DKA decreased.

Conclusion: A multifactorial approach integrated with psychosocial support will promote self-care activities and reduce the short- and long-term complications of T1DM in adolescents.

Keywords: Diabetic ketoacidosis, Insulin pump therapy, Continuous subcutaneous insulin infusion, Type 1 diabetes mellitus, Peer support (focused group discussions).

Introduction and Background

Type 1 diabetes mellitus (T1DM) is the most common debilitating chronic condition with the highest incidence diagnosed at age 14 (Norman, 2016). It is marked by the inability of the body to make insulin, resulting in lifetime insulin dependency that commands an unusual level of care. For those adolescents who use insulin pump therapy, the rate of hyperglycemia and diabetic ketoacidosis (DKA) is three times higher than in those using multiple-dose insulin (MDI) therapy (Brorsson, Viklund, Ortqvist, & Lindholm, 2015) and is associated with the extraordinary morbidity rate of 21–35% and a mortality rate of 21–24% (Harper et al., 2013; Norman, 2016).

According to the American Diabetes Association (ADA; 2014a), 18,436 youths were diagnosed with T1DM in 2009. The yearly rate of diagnosed T1D increased from 24.4 to 27.4/100,000 between 2002 and 2009 (Lawrence et al., 2014). A similar increase occurred in the Dutch youth population, with the largest occurrence in those ages 10–14 and 15–19, which was estimated to be 25.2/100,000 (Fazeli Farsani et al., 2016). T1D occurrences across Europe increased at a rate of 3-4% (Patterson et al., 2012). The disease causes acute complications such as hyperglycemia, DKA, hypoglycemia, and chronic microvascular complication of the nerves, eyes, kidneys, and heart due to hyperglycemia. These complications negatively impact the quality of life (QOL), increase mortality, and decrease the lifespan by 11–13 years (Katz & Laffel, 2015; Livingstone et al., 2015).

The Centers for Disease Control and Prevention (2012) reported that from 1968–1984 the mortality-rate trends in T1D adolescents aged 10–19 had decreased by a 6.5 annual percentage, but it was then followed by a 1.6 annual increase from 1984–2009. The cause of increase was not immediately identified, but the authors hypothesized the possibility that adolescents diagnosed

before the age of 10 were dying at 10–19 years of age, indicating the need to improve diabetic care among adolescents with diabetes. (Saydah, Imperatore, Geiss, & Gregg, 2012).

Grunberger et al. (2010) revealed that 47% of children with T1D above age 6 in the US were on the insulin pump therapy. A study by Ross, Milburn, Reith, Wiltshire, and Wheeler (2015) revealed that 40–45% of these children and adolescents experience adverse effects every year that negatively impacts their health: 18% are hospitalized; 2/3 of those hospitalized have DKA or hyperglycemia; while 1/3 suffer from hypoglycemia. This supported Realsen, Goettle, and Chase (2012), an earlier study that assessed the adverse events reported to the US Federal Drug Administration and showed that 43% of these events needed hospitalization due to DKA or hyperglycemia. DKA is the main cause for hospitalization and increased mortality and morbidity rate, and it remains the utmost cause of diabetic-related deaths in adolescents and children (Rewers, Dong, Slover, Klingensmith, & Rewers, 2015).

In their 2012 study, Realsen, Goettle, and Chase stated that adolescents and children on the insulin pump are at higher risk of DKA, with the rate ranging from 2.7 to 9 per 100 patients yearly. These findings are supported by Olinder, Nyhlin, and Smide (2010), who noted that the rates of hyperglycemia and DKA are higher in adolescents who use the insulin pump. Brorsson et al. (2015) compared 216 patients on the insulin pump therapy to a control group of 215 on MDI in a retrospective US study. The authors found that insulin pump therapy improved the glycosylated hemoglobin (HgA1c) in the first one year and reduced cases of severe hypoglycemia but increased the rate of hyperglycemia and ketoacidosis. DKA was three times higher in patients on the insulin pump therapy than those on MDI: 2.8/100 and 0.5/100, respectively.

According to Couch et al. (2008), diabetes self-management education is an integral part of T1DM care. Self-management education is needed to help patients adjust to the ongoing challenges of developmental changes with chronic disease to improve metabolic control, reduce complications, gain skills in self-management, or improve their QOL. A study conducted by the Diabetic Association of Pakistan from July 2011 to June 2012 found that lack of diabetic education was one reason for non-adherence to treatment. The authors recommended patient and family education to better understand the treatment regimen in order to improve adherence and decrease the complications (Riaz, Basit, Fawwad, Yakoob Ahmedani, & Ali Rizvi, 2014).

Problem Statement

The rate of hyperglycemia and DKA in adolescents with TIDM aged 12–18 on the insulin pump is three times higher than in those using multiple-dose insulin (MDI) therapy (Brorsson et al., 2015). The cause has been identified in recent studies as inadequate patient education, missed insulin boluses for meals and snacks, pump malfunction, poor diet, psychological effects, pubertal physiological changes, and adolescents' risky behaviors (Wherrett, Huot, Mitchell, & Pacaud, 2013). Longstanding hyperglycemia is the most significant risk factor for the development of grave micro- and macrovascular complications such as kidney damage, impaired vision, or foot ulcers that can lead to leg amputation (Levitsky, 2016). Good metabolic control can delay or prevent late complications as well as decelerate the progression of already-existing complications. Hinshaw and Basu (2015) concluded that routine care is not enough for obtaining metabolic control in adolescents with T1DM. The authors claim that educational programs integrated into routine care and promotion of the teenager's self-efficacy are most effective in glucose metabolic control. The DNP therefore initiated a weekly diabetic care education and peer

support group for adolescents with TIDM on the insulin pump to decrease the rate of hyperglycemia and DKA.

Literature Review

A comprehensive literature search for evidence addressing higher rates of hyperglycemia and DKA in adolescents aged 12–18 was conducted using World Cat to search PubMed, Medline Plus, Medscape, and government sources. A Google search was also used to retrieve articles from Embase and Medscape. The search included studies published from 2010 to 2016 in the English language only. Words used in the search were type 1 diabetes, adolescent, youth, insulin pump, diabetic ketoacidosis, and hyperglycemia. A total of 32 articles were retrieved. Seven articles were eliminated because of lack of value and relevance to the topic. The remaining 25 articles were then evaluated for quality and strength of evidence using the Johns Hopkins Nursing evidence-based practice (JHNEBP) model (Newhouse, Dearholt, Poe, Pugh, & White, 2005). A total of 13 articles were eliminated because of poor quality. Ten research studies, one clinical guideline, and one consensus statement from various pediatric organizations were chosen and included in the literature review. Four articles were systematic reviews with a strong evidence level of three and a high rating quality of A according to the JHNEBP rating scale, while three were controlled studies with level-one evidence.

Although the literature uncovered a wide variety of issues concerning adolescents with T1DM on the insulin pump relevant to the high rate of hyperglycemia and DKA, this review focused only on the problems identified as the most significant contributing factors for these conditions in this group. These factors included adolescence, insulin pump problems, inadequate diabetic education, missed insulin doses, and peer support groups.

Adolescence

Adolescence is a stage that has many developmental changes, and parental involvement in the disease management can hinder the child's medical self-care development. At the same time, strict family routines can inhibit the youth's full autonomy (Comeaux & Jaser, 2010). Moore, Hackworth, Hamilton, Northam, and Fergus (2013) found that the developmental change and the medical treatment are overwhelming for both the youths and the parents (Moore et al., 2013), and subsequent family stress can hinder the adolescents from maintaining both their lifestyle and their medical treatment.

Moreover, Naranjo and Hood (2013) state that 15–25% of youths with T1DM have depression and anxiety levels 2-3 times higher than those without the disease. These conditions are associated with poor disease outcome because of decline in self-care. Intentionally missed boluses or forgetting to bolus for meals can notably increase the HgA1c and lead to poor blood glucose control (Maahs, Horton, & Chase, 2010). The aberrant conduct of adolescents refusing to bolus for meals is related to self-esteem and emotional distress (Ashraff, Siddiqui, & Carline, 2013). To increase the ability for adaptation, Naranjo and Hood (2013) proposed increasing intercommunication and support by parents and friends. Social support and technology use can enhance self-efficacy. A cross-sectional study of 150 youths ages 5–20 determined that the use of an insulin bolus calculator decreased levels of HgA1c (Wilkinson, McFann, & Chase, 2010).

Insulin Pump Problems

Research has demonstrated that the insulin pump is safe for use by children and youths, and for over 30 years it has shown the benefit of better glucose control and reduction of hypoglycemia incidences (Kaufman, 2013). However, the use of insulin pump in adolescents aged 12–18 is deterred by the technology itself. Rosenbloom (2010) asserts that the causes of

poor glucose control in this age group are poor insulin pump operation and management skills as well as puberty or adolescence itself. Ross et al. (2015) argue that poor outcomes result from multiple factors including the pump and the users as contributing factors. Grunberger et al. (2010) affirm that both the parents and adolescents on insulin pump therapy express difficulties in mastering the essential skills needed to manage the pump. Both parties agree that these skills, which include insulin preparation, and loading and programming the pump, are a hindrance to self-management. Clayton-Jeter (2012) addresses the lack of proper education to enable mastering the skill to operate the insulin pump and recommends training the user on how to operate the pump and to understand its benefits and limitations. Comeaux and Jaser (2010) support the need for pump operation education by affirming that youth who are proficient in technology perform well in pump operation.

Missed Insulin Doses

Hanas, Lindgreen, and Lindbland (2009) found in another large landmark retrospective study conducted in Sweden in 1999 and 2000 that the DKA rate in children on the insulin pump was two times higher than in those on MDI. Totals of 5,168 and 5,460 children with T1DM ages 0–20 were studied in 1999 and 2000, respectively. In 1999, 382 children were on the insulin pump, and the number increased to 600 in the year 2000. The researchers identified the causes of DKA as missed doses (48.6%), pump problems (12.7%), infections (13.1%), social problems (1.4%), and unknown. Missed doses and technical pump problems remain the highest causes of DKA in children below age 20 using the insulin pump. Olinder et al. (2010) investigated 12 adolescents aged 12–19 with T1DM on the insulin pump. The authors found that missed insulin boluses with meals reflect the blood glucose level and are the sole cause of hyperglycemia and DKA in T1DM on the pump therapy. Maahs et al. (2010) argued that the pump has a built-in

application to aid in the quick calculation of boluses. At the same time, using a continuous glucose monitor (CGM) has another benefit. The CGM has the capability to give timely notification of high glucose level and imminent DKA, and in this way it allows action to prevent DKA.

Inadequate Education

Errors stemming from insufficient patient education on how to use the pump increase the occurrence of hyperglycemia, DKA, and elevated HgA1c (Clayton-Jeter, 2012). Wheeler, Heels, Donaghue, Reith, and Ambler (2014) asserted that 44% of these adverse effects are associated with poor patient education, reflected by Grunberger and colleagues (2010) as difficulty in mastering the skills needed to use the pump. Cannula plugging and dislodgement that cut off the insulin flow was reported to be a major cause of increased DKA in the youths using the pumps (Maahs et al., 2010).

The American Association of Clinical Endocrinologists (AACE) and the Center for Devices and Radiological Health (CDRH) recommend that patients must be well trained in the use of the pump before initiation and should receive continued education throughout the pump therapy (Clayton-Jeter, 2012). Comeaux and Jaser (2010) proposed the need to educate adolescents using the pump, stating that the patient should understand the meaning of alarms and signals of battery failure or interruptions. This is important to adolescents because research shows that young people who are proficient in technology perform well in pump operation.

Wherret, Huot, Mitchell, and Pacaud (2013) argued that adolescents with T1DM need aggressive diabetes education to furnish them with the required skills and knowledge to control the disease, adding that outpatient education for T1DM adolescents is less in cost and has better outcomes when the right content is provided.

Exercise

Riddell (2015) claims that regular exercising is beneficial in the prevention of heart disease and other forms of illness, lowers the blood glucose level, and enhances social interaction in T1D adolescents, but that it has a risk of hypoglycemia for the children on insulin pump therapy. Leclair, de Kerdanet, Riddell, and Heyman (2013) explain that in a study on T1D youths, aerobic and resistance exercises resulted in improved QOL by 4 to 34% in 3–9 months of exercise. Increased tissue response to insulin and improved glycemic control were also observed, resulting in decreased insulin requirement. The authors forewarn that a big reduction in insulin without a good balance of meals and exercise may result in hyperglycemia.

Value of Group Sessions—Peer Group

Abolfotouh, Kamal, El-Bourgy, and Mohamed (2013) conducted a quasi-experimental study with 503 adolescents with T1DM who were assigned to a control or an experimental group. The experimental group was subjected to a behavioral education program of four sessions of 120 minutes each over 4 months that included diabetic management and adherence to treatment. The results showed a notable adherence in the experimental group to exercise, glucose monitoring, treatment, self-efficacy, glycemic control, and satisfaction with life. Ashraff et al. (2013) observed that adolescents live in a social context of friends and peers. Their interviews revealed that peers and friends were a source of emotional support for adolescents with T1DM and were linked to compliance, good glycemic control, and QOL. Adolescents with T1DM peer groups have been used in various studies as an intervention to provide peer support and diabetic education with improved glucose control, diabetes-related stress, and social interaction (Kichler, Kaugars, Marik, Nabors, & Alemzadeh, 2013; Peters, Nawijn, & van Kesteren, 2014; Velicer, 2015).

Conclusion

The literature review revealed the need for increased diabetic education, pump operation skills, self-care and self-image, parental involvement in disease management, and the adolescent need for change in behavior. The aim of this quality improvement project was to implement an educational program encompassing pump operation skills, insulin bolusing for meals/snacks, carbohydrate counting, and glucose monitoring for T1DM adolescents age 12–18, and engage them in a peer group intervention to enhance their diabetic education and social support with the aim of improving self-care efficacy and decreasing the rate of hyperglycemia and DKA.

Theoretical Framework

The theoretical framework of this project was based on Orem's self-care theory (Orem, 1991). The focal point of Orem's theory is the act of supporting others in the delivery of their own care to sustain or improve their responsibility at home. It is geared to the effort that the individual patient implements and conducts on behalf of self in sustaining life, health, and well-being. Wayne (2014) in his discussion of Orem's' self-care theory defines *self-care* as the needed actions to permit independence. Self-care has three categories: (a) general self-care, which is related to the life process and sustaining of human dignity and biological functioning like breathing, eating, drinking, and elimination; (b) the normal condition that is concerned with genetics, traits, and talents; and (c) the development of self-care requirements that come with the illness or an event (Wayne, 2014; See Appendix A).

In this project, the DNP student applied interventions to assist adolescents with T1DM on the insulin pump to acquire the knowledge, skills, and the will to develop self-care actions needed to manage the consequences that accompany T1D in these adolescents. The activities focused on meeting the required needs to manage their own insulin pump, bolusing for meals,

maintaining the proper diet, exercises, and utilizing peer support to maintain well-being and to decrease the risk of hyperglycemia and DKA. This was capped with what Orem calls health deviation self-care needs—the sustainability of the actions and the adaptation of the individual patient to the effects of the illness, recognizing the disease ramifications, taking actions needed to improve the disease, responding to harmful events, changing self-image, and learning to live with illness (Orem, 1991; Wayne, 2014). This permanent transfer of self-care actions toward managing their disease was evaluated by their degree of adherence and compliance with self-care that will ultimately result in a decreased rate of hyperglycemia and DKA.

Project Design and Methods

The DNP student used a quality improvement project design and the plan, do, study, act (PDSA) methodological framework to initiate evidence-based educational interventions in adolescents with T1DM on the insulin pump therapy (US Department of Health and Human Services, Health Resources and Service Administration (2016). The project was initiated at four public schools in a public school district of western Massachusetts. Participants were a convenience sample of English-speaking adolescents living with T1DM using the insulin pump. They were chosen from two public middle schools and two public high schools. The inclusion criteria were adolescents age 12–18, living with T1DM, on insulin pump therapy, and enrolled in one of the four public schools.

The methods included pre- and post-intervention data comparison, analysis of the system of care delivery and process mapping. Tools used included pre- and post-intervention questionnaires for the nurses (Appendices B and C) and for the students (Appendices D and E). Analysis included both qualitative and quantitative methods. A peer support group was initiated and held meetings once a week. This was aimed at bringing the youths with TIDM together to

discuss difficulties and successes in their disease self-management and as a result support each other in improving their self-care skills. It was hoped that they would also make connections that would enhance their self-esteem. The peer group met weekly in the nurse's office for 15–20 minutes for 11 weeks under the leadership of the DNP student.

Goals and Objectives

The aim of the DNP student was to help the participants decrease their rate of hyperglycemia and DKA by applying evidence-based diabetes education and initiating support groups for them to support each other by discussing and sharing knowledge about their diabetes self-care, which would improve their self-care efficacy and their self-esteem. The evidence-based education was geared to improve their diabetic self-care in the following areas: calorie counting, insulin bolusing for meals and for snacks, insulin pump operational skills, and exercises. The outcome goals were as follows:

1. Decreasing fasting blood glucose >250mg/dl by 100%

2. Decreasing the rate of DKA by 100%

3. Improving psychosocial support and a sense of well-being by 50% through participation in the focus groups

Interventions

The questionnaire (Appendix D) aimed at identifying the students' perspectives on T1DM self-care while on the insulin pump, their level of skill in operating the pump, and the psychological effects relative to the demands of the disease. A post-intervention questionnaire (Appendix E) measured the effect of the program. Evidence-based educational sessions were held each week for 4 weeks. The lessons included the following:

1. Insulin pump operational skills and peer support in the school.

2. Signs and symptoms of hyperglycemia, hypoglycemia, and DKA, and actions to take if they occur.

3. Recommended diabetic diet, carbohydrate counting, and insulin bolusing

4. Physical exercises and blood glucose control in T1DM.

After the 4 weeks of education, the participants engaged in the peer support group meetings. They discussed one of the evidence-based diabetic education subjects of their choice each week, their success or failure in those activities, and what they could have done better. The DNP student was the guidance in these weekly meetings and added key evidence-based information on each of the items mentioned. After the meetings, each participant self-reported their weekly fasting glucose range, episodes of hyperglycemia, DKA, and exercise data for comparison with the previous week and overall evaluation of individual progress. Post-evaluation data were obtained through voluntary self-reporting,

Measures Used to Study the Interventions and Outcomes

The complexity of T1DM management in adolescents requires that the patient adhere to multiple self-care behaviors. Adherence is critical to effective healthcare, and assessment of the strategies relies on the measurement of self-management behaviors (Gandhi, Vu, Eshtehardi, Wasserman, & Hilliard, 2015). The measurement used was a subjective method and the tools were self-reporting in a pre- and post-intervention questionnaire and weekly reports. The pre-intervention questionnaire and weekly self-reporting questionnaire (Appendix F) were used to track the progress on various diabetic self-care behaviors. The participants rated the frequency at which they carried out the behaviors. Items surveyed weekly were calorie counting, blood glucose monitoring, episodes of hyperglycemia and DKA, and the weekly average level of

fasting blood glucose. The post-intervention survey was conducted to determine evidence of improvement in the level of self-care, insulin pump skills, and coping with the psychological effects brought about by the demands of the disease (See Appendix E).

The nurses were also given a pre- and post-intervention questionnaire (Appendices B and C). The pre-intervention survey for the nurses was aimed at assessing the time spent on health education for the adolescents with T1DM at school and getting a perspective of the nurses on the adolescents' self-care efficacy. The nurses' post-intervention questionnaire was aimed at getting their assessment on the effects of the project on the participants' self-care efficacy. The rationale for using questionnaires as a tool was the fact that they were cost effective, they were quick and easy for the adolescents to complete, and they helped to maintain privacy because they could remain anonymous (Sincero, 2012) which is key in adolescents. The tool was quick, efficient, and successful in getting the precise information needed. It was also effective in allowing the analysis of multiple variables.

The project processes were also evaluated to determine if they were followed as planned and if they affected the results. The process indicators included compliance with diabetic diet and calorie count, compliance with exercises, compliance with checking glucose level at a minimum of three times per day, insulin bolusing for snacks and meals, and engaging in the weekly support group. The outcome indicators were a reduction in the episodes of hyperglycemia and DKA, and an increase in self-esteem.

Description of the Group, Population, or Community

The adolescents living with T1DM in these schools have private insurance and come from primarily middle-class families. According to the US Census Bureau (2015), the Hampden County population where this school district is located is estimated to be 470, 690. Persons under

5 years of age are 5.8%. Persons under 18 years are 22.3%, while those 65 years and over are estimated to be 15.5%. The area is predominately White, at 83.3%; Black and African Americans are 10.8%, white non-Hispanics are 64.1%, and Hispanics 24.1%. Persons below the poverty level in this county are 17.7%, according to the 2010–2014 American Community Survey 5-Year Estimates. The project participants were a convenience sample of English-speaking adolescents 12–18 years of age living with T1DM on the insulin pump in four public schools in one district of western Massachusetts. This school district has four high schools and three middle schools.

Stakeholders' Support

The principals of the four public schools and the district nursing supervisor approved the project.

Ethics and Human Subjects

The DNP project was reviewed by the University of Massachusetts Amherst Human Research Protection Office (HRPO) and was granted a letter of exemption (see Appendix G). The participants were fully informed about the project activities and timeline and were given one (1) month to make a decision to participate. Because the participants were minors, parents/guardians were involved to ensure an informed decision. A letter with full information about the project was sent to the parents 1 month prior to initiation to agree or deny the participation. The participation/enrollment in the program was voluntary. The program posed no harm to human participants and the gain from it could potentially improve the disease outcome and QOL. Every participant was given equal opportunity, and privacy of individual information was maintained to protect the participants. No identifying information was collected.

Results

A total of 20 qualifying participants enrolled for the project; four dropped out before the end. Of the 16 youths who completed the project, 25% were in middle school and 75% in high school. Male participants were 56.3%, and females were 43.7%. Hispanic students were 18.75%, Blacks were 6.25%, and Whites were 75%. The 16 participants included in the data analysis had a 100% attendance in the educational sessions and attended the peer support group for six or more sessions during the program time period. Process data were collected weekly through the participants' self-reporting of self-care activities (see Appendices H and I). Data of all items covered were self-reported by the participants weekly with an exception of the HgA1c. The HgA1c is measured every 3 months at the earliest; otherwise it is done every 6 months. Only two of the self-care processes attained the goal of 100%. Information bias cannot be excluded as the data were self-reported.

Insulin bolusing for meals and snacks: Bolusing for meals showed a quick and steady improvement over time and reached the 100% goal by the end of the program. Success in this self-care activity was reflected in the improvement of the fasting blood glucose level each week. In spite of that, insulin bolusing for snacks improved slowly but steadily; 87% of the participants were regular in bolusing for snacks. The deficit correlates with the fasting blood glucose values. Only 81.25% of the participants were able to control the fasting glucose to below 200g/dl.

Insulin pump skills: Most of the participants were proficient with this skill, as was demonstrated in the pre-intervention data. Nevertheless, a few were still struggling to master the pump operation skills.

Number of blood glucose level checks per day: In the pre-intervention data, most participants checked their blood glucose twice daily. It was also noted they did not have a

continuous glucose monitoring (CGM) device. This resulted in missed opportunities to address elevated blood glucose level, thus resulting in high HgA1c, as seen in the pre-intervention data. By the end of the educational program, the participants increased the number of times they monitored their blood glucose level in a day to three or more times before meals by 50%. This improvement directly relates to the increased insulin bolusing for meals and the concurrent reduction in the fasting blood glucose levels.

Blood glucose level: The DNP student established a fasting blood glucose level of equal to or below 200g/dl as the benchmark. Initially, only 50% of the participants had met the goal, but their blood glucose control improved slowly as the rest of the self-care activities improved. By the end of the program, 81.25% had attained the goal, which was a 31% improvement.

HgA1c: The benchmark for HgA1c was 7% or less as recommended by the ADA (2014a). Prior to the program, all participants had an HgA1c greater than 7%, except three of the 16 participants. Data were missing because HbA1c is monitored every 6 months for those with controlled diabetes and every 3 months when uncontrolled. Only four participants had their HgA1c scores checked at the end of February and only one of them had a level below 7%. This was an expected result because HgA1c is not expected to drop in such a short period of time despite the improvement in daily fasting glucose levels.

Exercises: Physical exercise was measured by participating in 10–15 minutes of exercise daily. The exercises were walking, running, sports, or gym. There was no improvement in increasing physical activity, and the item was noted as an extreme outlier. Only 37.5% of the students were engaged in sports prior to the intervention, and they maintained their physical activity level throughout the program period. The participants cited the poor winter and spring weather for their low participation in outdoor activities.

Self-esteem: Self-esteem was measured weekly using one question that required the participant to self-report how satisfied they were with themselves. The question had four choices of strongly agree, agree, disagree, and strongly disagree. Only the highest score of strongly agree was analyzed as positive self-concept. There was improvement of 31% in this area. Irregularity of some of the students choosing not to answer could have contributed to bias but a "no response" was treated as disagree.

Overall, great improvement was noted in all areas of the survey. A qualitative method was also used in this project to count the attributes of self-care. These qualitative data were classified and summarized, and are presented in Table and Figure 1 and Table and Figure 2 (Appendices H and I).

School nurses: The pre-intervention survey to the school nurses revealed that most of them spent 10 or more minutes with an adolescent living with T1DM in a normal school day. Only one nurse reported that she engages the youth in discussing the insulin pump skills. Only one nurse responded that she often does. The other nurses presumed that the participants had good knowledge of the pump operation skills. According to the responses, none of the nurses gave formal education on T1DM self-care management to the students. In rating compliance with the diabetic self-care efficacy, 75% of the nurses said that this item was variable and ranged from good to poor depending on the individual participant. On the other hand, the post-intervention survey contradicted the pre-intervention data. Most of the nurses reported that the participants were proficient in self-care, which was contrary to their prior responses and the weekly data collected by the DNP student. The data showed many areas of self-care deficits and revealed an improvement of self-care activities over time.

Facilitators and Barriers

One of the greatest facilitators was the availability of participants in the school district and the school's availability for use as a meeting location. The school nurses were also facilitators of the project because they kept time to release students for the meeting during their free lesson. They also assisted in passing the letter to the parents/guardians for information and enrollment authorization. The nursing supervisor supported the DNP student by passing important information about the project to the nurses and by accompanying the DNP student to the support group. In her absence, she allowed the nurse coordinator to travel to each school with the DNP student for the support group sessions. The nursing supervisor was on the frontline of the project. She wanted the improvement project in her schools because it supported her public health agenda.

The biggest barrier to the project was time. The peer support groups met 15–20 minutes during the free period. This time was not sufficient to engage in a deeper interaction. On the other hand, it had to be kept short to allow the participants to attend their classes without interruption.

Inclement weather was another barrier because school closings for winter weather. This happened on two days that had been scheduled for the meeting. Additionally, school had a spring break during this period. The two events delayed the program's completion and data collection.

Discussion

Summary and Interpretation

The purpose of this study was to decrease the rate of hyperglycemia and DKA in adolescents living with TIDM who are on the insulin pump by use of evidence-based education and peer support. Malik and Taplin (2014) found that both MDI treatment and continuous

subcutaneous insulin infusion (CSII) therapy in adolescents with T1DM must be supported by comprehensive education that is appropriate for the individual needs of the patient before and after initiation. These findings indicated that the evidence-based educational program was effective in improving self-care skills in adolescents with T1DM who use the insulin pump. The outcome showed that when knowledge of self-care management improved, the complications of TIDM such as hyperglycemia and DKA decreased. These findings are congruent with Pelicard, Maes, Charlier, and Aujoulat (2012) who found a relationship between HgA1c and the self-reported level of self-care in adolescents with T1DM. The authors state that the adolescents who had good glycemic control reported independence in complex self-care behaviors (Pelicard et al., 2012).

Significant improvement in carbohydrate count was noted. This is in alignment with the ADA recommendations that carbohydrate counting is the first tool for managing blood glucose levels because the amount of carbohydrates in food is directly related to the blood glucose response (ADA, 2014b). The results of the program concur with this finding. Bolusing for meals and snacks attained 100% and 87.5% scores, respectively. Adherence to insulin bolusing was noted to control their daily blood glucose level below 200mg/dl. This finding was significant because missed insulin doses was found to be one of the highest causes of hyperglycemia and DKA in adolescents with T1DM (Olinder et al., 2010).

Peer support was found to be a tool to support the participants by discussing self-care and sharing life experiences 50% of the participants self-reported a sense of well-being. According to Herzer and Hood (2010) and Naranjo and Hood (2013), adolescents with T1DM often experience the opposite of well-being with an increase of self-reported anxiety symptoms, including depression. Anxiety and depression are associated with poor glycemic control and

disease management outcome in adolescents. The participants in this program shared life experiences and their ideas about how to avoid or navigate episodes of hypoglycemia and hyperglycemia when they occur during school hours. The finding demonstrated that psychological welfare correlates with improved glycemic control and improves the adolescents' QOL.

Physical activity increases insulin sensitivity, lowers the blood glucose level and lowers the HgA1c in the long term (ADA, 2013). This is an achievement this program was not able to attain. It remained an isolated item among all other items. Only 37.5% of the participants were engaged in regular indoor sports. After reviewing this item with the participants, they cited the cold unfavorable weather in the winter and spring that does not support outdoor activities.

Limitations

A few limitations were experienced in this project. The time to meet with the focus groups was limited because the meetings occurred during school hours. The conflict with classes was difficult and the DNP student ensured that the students did not miss their classes and therefore limited the meeting time to 1,520 minutes a week. This time was not enough to allow the adolescents to share more of their knowledge and self-care in depth. In the future, the DNP would recommend the meeting time be adjusted and be held in the evening after classes. Likewise, the participants were in different classes so not all of them would be available for the meeting each week. This led to four participants dropping out of the program. Although this happened, the attendance remained above 90% each week. Similarly, the participants were in different schools. This was hard for the DNP student in making sure that she would be on time in each school given the distance between the schools. This will need further exploration to determine if results would improve with changing the meeting venue to a central area around the

schools. Another limitation was that 12% (2/16) of the participants chose not to respond to self-esteem questions. The "no response" was analyzed as "no positive attitude toward self." When hyperglycemia decreases, over time it will decrease the HgA1c. Not many HgA1c scores were obtained at the end of the program and, because of that HgA1c missing data, the results may not reflect the actual outcome. The DNP student suggests that future programs should continue for more than 6 months to get results that are reflective of the program outcome.

Implications for Practice

Engagement of clinicians and other professionals in the education of adolescents with T1DM under their care to improve self-care management may improve outcomes. It has been demonstrated in this project that if the patient/client has sufficient knowledge of the disease they become proficient in self-care, resulting in a better disease outcome. Additionally, there is need for public schools to initiate self-management education programs to support adolescents with T1DM. Such educational programs should incorporate a social support system that can support parents in the care of their loved ones. Support of the parents will help their adolescents to acquire self-care skills and to maintain their self-care behavior.

Conclusion

To decrease episodes of hyperglycemia and DKA, it is recommended that evidence-based diabetic education be provided to youths with T1DM to facilitate their self-care activities. A multifactorial approach integrated with psychosocial support will promote self-care activities and thus decrease or halt the short- and long-term complications of T1DM.

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Appendix A

Orem's Self-Care Theory

From G. Wayne (2014). Nurses Labs. Reprinted with permission.

Appendix B

Survey Questionnaire for Nursing Staff

All these questions pertain to adolescents with T1DM on the insulin pump.

Instructions: Choose the most correct answer.

1. What is the average time you spend in one week with a T1DM adolescent providing education about the disease management, self-care, diet, and medication dosage?

    1. 2 minutes or less
    2. 5 minutes or less
    3. 10 minutes or less
    4. More than 10 minutes
    5. I don't know
    6. Free answer (numbers only) _____

2. Do you discuss the use of insulin pump with those adolescents on the pump therapy? Yes___ No___. If yes, how would you rate their overall understanding of pump operation?

    1. Poor
    2. the post-intervention Good
    3. Very Good
    4. Excellent

3. Do you give health literature handouts to those adolescents? Yes___ No___
If yes, how would you rate the T1D adolescents' understanding of the health literature?

    1. Poor
    2. Good
    3. Very good
    4. Excellent

4. How would you rate their compliance with treatment, insulin dosing, carbohydrate counting?

    1. Poor
    2. Good
    3. Very good
    4. Excellent

5. How would you rate their level of self-care?

1. Poor
2. Good
3. Very good
4. Excellent

6. What would you like improved in the care of the T1D adolescent on the insulin pump?

Free entry:

Date _____

Thank you for your help.

Appendix C

Post-Intervention Questionnaire for Nursing Staff

All these questions pertain to nursing staff working with adolescents living with T1DM on the insulin pump.

Instructions: Please answer all the questions.

1. On your assessment, did the program improve the participants' coping skills and self-esteem? Yes___ No___. If no, what should be improved?
   1._____2._____

2. On your assessment, did the program help the participants improve their diabetic self-care? Yes___ No___. If yes, what was improved? Arrange items in order of most improved to least.

   1._____ 2._____

   If no, what did not improve and why?

   Free entry:

Date _____

Appendix D

Initial Questionnaire for Students

1. What kind of insulin pump do you have?

_____

2. What kind of insulin are you on?

    1. Insulin lispro (Humalog)
    2. Insulin aspart (Novolog)
    3. Glulisine

3. How competent are you in operating your insulin pump?

    1. Competent
    2. Somewhat competent
    3. Not competent

4. How often do you check your blood sugar?

    1. One time daily
    2. Twice daily
    3. Three times daily
    4. More than three times daily

5. How comfortable are you in carbohydrate counting?

    1. Comfortable
    2. Somewhat comfortable
    3. Not comfortable

6. Do you always bolus for food and snacks?

    1. Yes
    2. No

        If no, why? 1. _____ 2. _____

7. What is the range for your blood sugar level?

_____

8. Do you know your current A1C?

    1. Yes   If yes, what is it? _____
    2. No

                               Date _____

Appendix E

Post-Intervention Questionnaire for Students

1. How competent are you in operating your insulin pump?

1. Competent
2. Somewhat competent
3. Not competent

2. How often do you check your blood sugar?

1. One time daily
2. Twice daily
3. Three times daily
4. More than three times daily

3. Do you have a continuous glucose monitoring device? Yes……No ……

4. Do you always count your calorie intake? Yes_____ No_____ If no, give two reasons

   1_____ 2._____

5. Do you always bolus for snacks? Yes_____ No_____ If no, why? Give two reasons

   1. _____2. _____

6. How many times do you exercise or engage in indoor sports per week?

1. One time for at least 30 minutes
2. Two time for at least 30 minutes each time
3. Three times for at least 30 minutes each time
4. More than three times for at least 30 minutes each time.

7. Do you know your current A1C? (Indicate A1C for February and March only)

   _____

                                                    Date _____03/07/2017

Appendix F

Weekly Questionnaire

This survey is for students living with T1DM on the insulin
pump who are enrolled in the diabetic focus group.

Over the past week, on average, how many blood glucose checks did you complete per day?

1. Less than three

2. Greater than three

What was the average blood glucose daily? Free entry……………………………………………….

Over the past week, on average, how many times did you perform calorie count per day?

1. With all meals
2. With all snacks
3. With most snacks and meals
4. With all meals and snacks.

Over the past week, on average, how many times did you miss giving yourself an insulin bolus for snack or meals?

1. All the time
2. Half of the time
3. More than half of the time.
4. None

Over the past week, on average, how many times did you exercise for a half hour (30 minutes)?

1. None
2. Two times
3. Three times
4. More than three times

Overall, I am satisfied with myself

1. Strongly agree
2. Agree
3. Disagree
4. Strongly disagree.

Appendix G

HRPO Letter of Exemption

University of Massachusetts Amherst   Human Research Protection Office

Mass Venture Center   Research Compliance
100 Venture Way, Suite 116
Hadley, MA 01035
Telephone : 545-3428 FAX : 577-1728

MEMORANDUM

To: Jane Macharia, Nursing
From: Human Research
Protection Office Date:
December 8, 2016

Project Title: *Decreasing Hyperglycemia and Diabetic Ketoacidosis for Adolescents on Insulin Pumps: A Quality Improvement Project*
IRB Number: 16-159

The Human Research Protection Office (HRPO) has evaluated the above named project and has made the following determination:

☐The activity does not involve research that obtains information about living individuals and therefore does NOT require IRB review and approval.

☐The activity does not involve intervention or interaction with individuals OR does not use identifiable private information and therefore does NOT require IRB review and approval.

☒ The activity is not considered research under the human subject regulations (Research is defined as "a systematic investigation designed to develop or contribute to generalizable knowledge.) and therefore does NOT require IRB review and approval.

☐ The activity is determined to meet the definition of human subject research under federal regulations and therefore DOES require submission of applicable materials for IRB review.

For activities requiring review, please see our web pages for more on types of review or submitting a new protocol. For assistance do not hesitate to contact the Human Research Protection Office at 545- 3428 for assistance.

APPENDIX H

Table 1.

Process Indicators (Self-Care Data Analysis)

	Calorie counting	Blood sugar Check at least 3x/day	Always Bolusing for snacks	Always Bolusing for meals	Exercise 3x/week	Pump skills proficiency	Self-Esteem
Baseline	81.25%	37.5%	56.25%	62.5%	37.5%	87.5%	50%
Target Goal	100%	100%	100%	100%	80%	100%	100%
01/24/17	81.25%	68.75%	68.75%	62.5%	37.5%	87.5%	50%
01/31/17	87.25%	87.5%	68.75%	68.75%	37.5%	93.75%	68.75%
02/07/17	87.25%	87.5%	75%	81.25%	37.5%	93.75%	68.75%
02/14/17	93.75%	87.5%	81.25%	93.7%	37.5%	100%	75%
02/21/17	N/A	N/A	N/A	N/A	N/A	N/A	N/A
02/28/17	93.75%	87.5%	81.25%	100%	37.25%	100%	81.25%
03/07/17	93.75%	93.7%	87.5%	100%	37.5%	100%	81.25%
03/14/17	*	*	*	*	*	*	*
	93.75%	93.75%	87.5%	100%	37.5%	100%	81.25%

N/A School spring break *Snow day

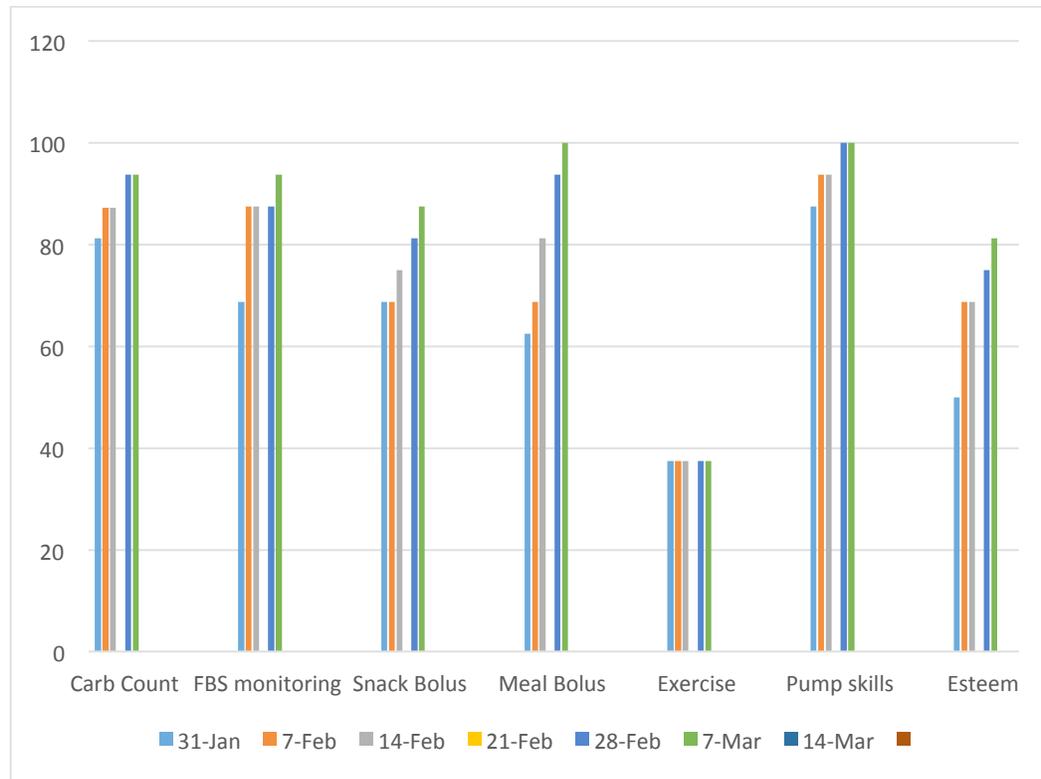*Figure 1.* Process indicators.

APPENDIX I

Table 2.

Outcome Indicators

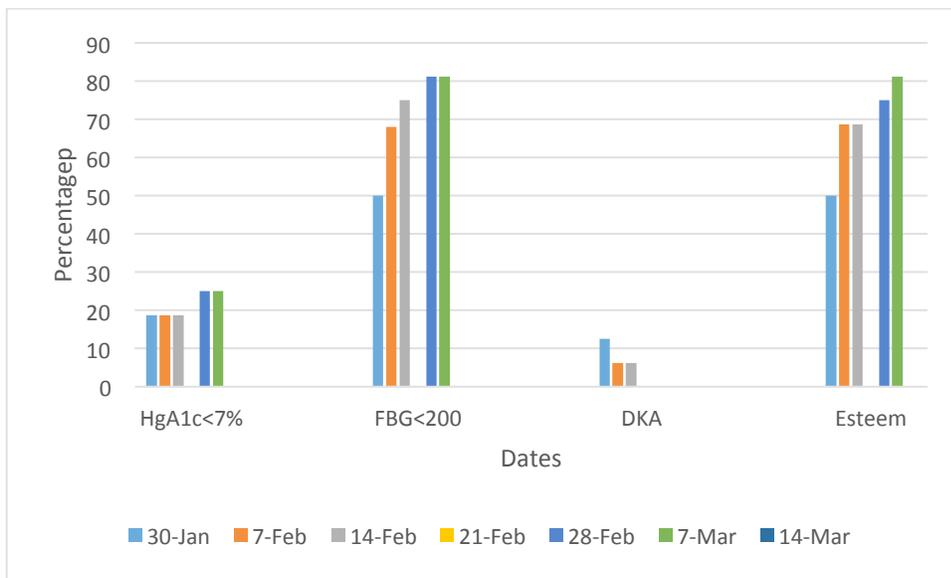|	HgA1c less than 7%	Weekly fasting blood glucose average <200g/dl	Monthly episodes of DKA	
Baseline	18.75%	50%	12.5%	50%
Target goal	50%	100%	0%	100%
01/31/17	18.75%	50%	6.25%	50%
02/07/17	18.75%	68%	6.25%	68.75%
02/14/17	18.75%	75%	0%	68.75%
02/21/17	N/A	N/A	N/A	N/A
02/28/17	25%	81.25	0%	75%
03/07/17	25%	81.25%	0%	81.25%
03/14/17	*	*	*	*
	25%	81.25 % (13)	0%	81.25%

N/A School closed *Snow day

Figure 2. Outcome indicators.