**Analyzing the Personalized Factors for Better Blood Glucose Control for a Type 1 Diabetic**

**Abstract**

Managing Type 1 Diabetes requires consistent monitoring and many adjustments to insulin, diet, and lifestyle. The timing of insulin doses, meals, physical activity, and other daily routines plays a very critical role in staying within a healthy blood glucose target range. A structured daily schedule and healthy routines - whether at home, at school or at work - helps diabetics maintain that control by ensuring consistency and oversight in accurate insulin delivery, carbohydrate intake, and exercise, which minimizes fluctuations in blood glucose levels. This paper explores the factors that might explain and predict glycemic control in a healthy target range. By understanding and taking action on these factors on a personalized, prescriptive basis, this can lead to improved blood glucose control, fewer complications, and better overall health outcomes for individuals with Type 1 Diabetes.

**Introduction and Background**

Some of the better resources available, providing guidance to patients and parents of diabetics include an article about diabetes management from the Mayo Clinic. [**https://www.mayoclinic.org/diseases-conditions/diabetes/in-depth/diabetes-management/art-20047963**](https://www.mayoclinic.org/diseases-conditions/diabetes/in-depth/diabetes-management/art-20047963)

This article addresses how lifestyle and routine affect blood sugar levels. The importance of planning balanced meals and carbohydrate counting is instrumental. It also recommends regular exercise and understanding ones blood sugar levels prior to exercise. Managing medications appropriately and being prepared for times of illness are also important.

Another great resource recommending daily routines is from PEAQ Medical. [**https://peaqmedical.com/daily-routines-for-managing-diabetes-a-step-by-step-guide/**](https://peaqmedical.com/daily-routines-for-managing-diabetes-a-step-by-step-guide/)

It provides a step-by-step guide for living daily with diabetes. It mentions having a good routine for the day helps to provide better control. Meal planning, proper exercise and monitoring are all important in establishing a routine that should be followed for healthy blood glucose control.

Adolescent patients with diabetes and their parents or caregivers should refer to sites explaining the medical devices they use to control their blood glucose levels. A good example of this is The Tandem Diabetes site for their products. [**https://www.tandemdiabetes.com/products/software-apps/mobile-apps**](https://www.tandemdiabetes.com/products/software-apps/mobile-apps)

It provides details about how to use their products effectively and how to get any needed support for managing the disease with their products.

Studies on data-driven modeling and predictions of blood-glucose in patients with Type 1 Diabetes have been done, including a paper from Pubmed <https://pubmed.ncbi.nlm.nih.gov/31383477/> which highlights the advances in Continuous Glucose Monitoring (CGM) technologies and potential for Machine Learning algorithms to use patient historical data to better predict blood glucose, thereby enhancing closed-loop Artificial Pancreas solutions to manage diabetes. Unfortunately, a universal model producing accurate predictions for each patient or each circumstance has proven difficult.

As a parent of multiple diabetics, I value sources of great information and products that companies like Tandem Diabetes make to help families manage the disease. I have also received wonderful advice from endocrinologists and have also read many articles from reliable sources about strategies for better blood glucose control.

There is a good deal of learning and daily struggle for a person dealing with Type 1 Diabetes. It can be particularly more challenging when going through adolescent body changes and the desire to fit in and be ‘normal’. Patients with diabetes are encouraged to meet with their endocrinologist on a quarterly basis to review their health and make needed corrections as they grow and as the disease progresses. Common adjustments needed include the insulin basal rate (the amount the body needs, even without food), the bolus amount (insulin to carbohydrate ratio), and the correction bolus rate (amount of insulin needed to lower a high blood sugar level). These adjustments also need to account for the time of day, as insulin needs vary based on time of day or night. In addition to all of this, a diabetic needs to be aware of the effects of exercise (or lack thereof), stress, hormonal changes, and sickness on their blood sugar levels.

For each diabetic and their caretakers, making daily decisions about each of the factors affecting blood glucose have the inherent goal to bring or keep them in a healthy target range one to three hours in the future.

There are certain factors that can derail efforts for healthy blood sugar control. These are usually the very same factors that compromise anybody who has tried to stick to a weight loss goal. When one lacks a structured daily schedule, has access to unhealthy food at all times of the day (and night), has varying times for meals and inconsistent serving size and composition of nutritional makeup, blood sugar control can be compromised. Additionally, the lack of qualified adult supervision for children and adolescents with the disease while away from home can negatively affect blood glucose levels.

**What is already being done**

Most CGMs do a good job alerting high and low blood glucose levels. They also can use the information from the monitor to create and even share time series graphs and detect patterns based on time of day. These are very useful to help the diabetic and their caretakers in the understanding and correction of trends for those times of day experiencing high or low levels of blood glucose.

Some CGMs are also capable of connecting with insulin pumps to automatically increase insulin dosing with a ‘bolus’ when glucose levels are high. Similarly, they can pause ‘basal’ insulin when it is detected that glucose levels are low or quickly dropping.

New and emerging technologies have even given rise to an Artificial Pancreas which combines the CGM with an insulin pump and an algorithm to determine proper insulin delivery in real time. Some of these even include glucagon as counterpart to insulin to prevent hypoglycemia. These technologies have been going through extensive regulatory approvals the last few years to assure they are safe and effective.

One of the most challenging aspects of accurate insulin delivery remains the variable amount of carbohydrate intake for the diabetic patient. Although there are great applications and ways to help diabetics understand the nutritional information in food products, especially the grams of carbohydrate, it is critical to the calculation of insulin needed that they correctly enter the quantity of carbohydrate that will be consumed in advance. Individual serving sizes of common snacks is helpful to maintain consistent portion sizes, which is important for understanding insulin needs.

**Main Questions**

Having a better understanding of the effects of actions or inactions relating to structuring a good daily schedule and healthy habits impacting blood glucose control will help diabetics and families like ours to better plan and prepare our home environment as well as giving those with diabetes the necessary tools and information to achieve that important control away from home and when they venture out in life more independently. It can also be used as a starting point for discussions with their endocrinologist for good strategies to improve their daily health habits.

What measurable variables are key contributing factors to achieving good blood glucose levels? Are there certain times of day or places that the diabetic is in better control? Can information available from the CGM and insulin pump reliably predict future blood glucose levels for given patient? These are all questions I will attempt to answer in this analysis project

**Objective and Hypothesis**

The objective of this project is two-fold:

To understand the relationship of day types on blood glucose control. Does being at school or work versus at home have a better outcome for mean blood glucose levels? I will test the hypothesis that the mean blood glucose is the same for school or work hours versus at home against the alternative hypothesis that there is a difference between those times.

Can a predictive model be developed with reliable accuracy to predict whether or not the patient will be in his target blood glucose range most of the time one to three hours in the future? I will create a logistic regression model with the data available in the CGM and pump to answer this question.

**Data Description**

The data for this analysis and modeling project will come from the information downloaded from my two sons T-Slim insulin pumps and Dexcom CGMs over a period of two months.

The data contains the measurement of blood glucose levels every 5 minutes -- assuming the pump is operating as it should. The data also contain events associated with the delivery of insulin amounts at meal and bolus correction times.

**Methodology**

The data will need some categories built to create groupings used for the analysis. Identifying which days were school days and the times of day in school (or work) was held will need to be derived. I will also create groups for weekdays versus weekends, times of day windows and other such categories would also be helpful.

As much of the variability will likely come from insulin delivery (or lack thereof) at mealtimes, creating some variables calculating the amount of carbohydrate entered into the pump will surely be important.

A paired t-test on a sample of the data in each day type category will be used to test the hypotheses about differences in average blood glucose levels. It will also be important to observe exploratory statistics on the key variables to understand distributions and potential outliers and how to handle any missing data.

After understanding data distributions, I intend to build a logistic regression model for each of my sons data. I will use the first month of the data for training the model and the second month data for testing that model. Certainly I will need to check for collinearity of the explanatory variables and weed out those that don’t improve the models performance. I will look at model accuracy, precision and variance inflation among the predictors.

Which datasets are you using (or from where are you collecting the data)  
Descriptive Statistics (of the clean up data)  
Tests (why did you chose those tests to answer the questions)  
Part 3  
Results:  
Data analysis: test your hypothesis  
Figures (tables) that best illustrate your results (at least 2 or 3). Visualization is the window to your  
work, good visualization will enhance and gives the reader a good change in understanding your  
work. Bad visualization can kill your work (even if it is a good research)  
Conclusions:  
How do the results fit in the larger picture of this research domain? Tide these results to the intro.  
What's next:  
References (example)  
1. Stephen, H. F. et al. Improved Survival with Ipilimumab in Patients with Metastatic Melanoma. N.  
Engl. J. Med. 363, 711–723 (2010).