Impact of Hyperglycemic event on Mean Blood Sugar

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INTRODUCTION

Type 1 Diabetes Mellitus (T1DM) is a condition in which the pancreas of the patient produces little to no insulin. Insulin helps to breakdown carbohydrates into glucose and maintain our blood glucose level. On diagnosis of T1DM, the patient must inject insulin into his body through multiple daily injections or an insulin pump to keep their blood sugar in range. Recent technologies have also enabled patients to monitor their blood sugars by attaching a coin sized device that would read their blood sugars every 5 minutes.

Blood sugars from a CGMS can be utilized in multiple ways, even to predict future blood sugars. But at the same time, it is important to understand the impact of major events in the lives of Type 1 Diabetics. This can be done by looking at the past data and analyzing the same to understand its effects.

Aim: To find the effect of deviation in blood sugars for a few hours on the mean blood sugar for period of 1 week, 1 month and 3 months.

SPECIFIC RESEARCH QUESTION

1) What is the impact of 1 major hyperglycemic event on average blood sugars on a period of 1 week, 1 month and 3 months?
2) What is the impact of 1 major hyperglycemic event on the standard deviation of blood sugars on a period of 1 week, 1 month and 3 months?

METHODOLOGY

In this section, an all-inclusive narrative of the included data, analysis done on the data, and investigational setup is provided.

We followed the following steps to analyze the data to answer our research questions.

1) Data Collection
2) Data Cleaning
3) Data Analysis

1) Data Collection

The data used in the study was acquired over a period of 3 months from the Continuous Glucose Monitoring Device of a type 1 diabetic patient. The patient was put on Medtronic CGM sensor and was asked to continue with his daily schedule as usual to watch any ups and downs that occurs in the life of a type 1 diabetic. The Medtronic Guardian Sensor 3 would capture blood sugar levels every 5 minutes and was downloaded at the end of 7 days. We gathered approx. 288 blood sugar reading in 1 day.

CGM readings often don't send some blood sugar readings due to lack of calibration, connection or any other problem that it may face. Motivated from the international CGM consensus, we only considered the days that had more than 70% blood sugar readings available with us. There were no such days that had to be discarded for the above reason.

The accuracy of the CGM is trustworthy with a MARD (mean absolute relative deviation) of 8.8%. Other than the blood sugar level, we also had other data parameters like the basal rate, corrective boluses, meal boluses and meal carb entry. Although there were other data parameters available, we did not take into account any of these.

2) Data Cleaning

The data that was downloaded was in .xls format with multiple empty fields like BG Source, BG Reading (mg/dL), Linked BG Meter ID and various other fields. It is to note that BG Reading mentioned here is referred to the reading that has been received from an external source for calibration and not from the CGMS itself. The empty fields were dropped, along with other fields that were not required for research purposes. This included, Bolus Type, Bolus Volume Selected (U), and many other.

The final excel sheet included only date, time, and blood sugar columns. The date and time column were merged using to_datetime from pandas library. This

was done to make the dataset more readable and understandable.

As mentioned above, there were some inconsistencies in the BG data received from the Guardian Sensor 3 CGMS. The record with missing values were not discarded. It was also noted that there were no more than 6 missing values at a stretch which accounts for a period of 30 mins of no data from the CGMS. It was observed that there were no days where the missing values would exceed 14 data points, ie, 70 mins of unrecorded data in total in the whole day.

To rectify the 30 mins gap, we used the linear interpolate method to fill the missing values. These new values that were filled were a mean of the closest 2 values available to the missing data point. Linear interpolation ignores the index and treats all values as equally spaced.

The values filled using interpolation included decimal values. They were rounded off to nearest unit's place. This was done using round function of python.

3) Data Analysis

a) Mean

Mean or average is the ratio of sum of all the blood sugar readings in a given period to the number of blood sugar readings summed up. It will give us the average blood sugars in a particular period.

b) Standard Deviation

Standard Deviation is a statistic measure that will tell us how far a particular blood sugar is deviated from its mean. It is calculated using $\sigma = \sqrt{\frac{\Sigma(x_i-\mu)^2}{N}}$ where σ represents the standard deviation. X_i is a blood sugar value at a particular time, μ represents the mean of blood sugars and N is the total number of blood sugars taken for the mean.

To answer our research questions, we first find the mean of blood sugars of 3 months. The result is given below in Table 1.

Time Period	Mean Blood Sugar
3 months	136.5

We then proceed to find the mean of blood sugars for each month. It is given below in Table 2.

Time Period	Mean Blood Sugar (MBS)	Deviation from MBS
Month 1	140.75	4.25
Month 2	133.35	-3.15
Month 3	135.4	-1.1
	136.5	3.11 (Standard Deviation)

We see that mean of blood sugars in month 1 is highest when compared to others and the deviation from mean is highest as well. We will dive deep into this month to see in which week the blood sugars are highest.

Time Period	Mean Blood Sugar	Deviation from MBS
Week 1	134.6	-6.15
Week 2	135.2	-5.55
Week 3	157	16.25
Week 4	136	-4.75
Average	140.75	9.424

It is clear that in week 3 of month 1, there is an inconsistent MBS with 157 and deviation from mean blood sugar is 16.25. To have a closer look at week 3, we see mean blood sugars of each day to analyse if the patient had inconsistent blood sugars for the whole week or just a single day.

Time Period	Mean Blood Sugar	Deviation from MBS
Day 1	135	-22
Day 2	133	-24
Day 3	136	-21
Day 4	143	-14
Day 5	286	129
Day 6	137	-20
Day 7	132	-25
Average	157	52.59

We can see that on deeper analysis, day 5 has the highest average blood glucose of 286. It is also clear that on day 5 deviation is highest at 129 when compared to others which are negative and closer to 20. On finding the maximum value of blood sugar on that particular day, it is noted that it reached a peak value of 410. The normal range of blood sugar is 80-140mg/dL as defined by the American Diabetes Association. It was also seen that blood sugars were above the normal range (80-140 mg/dL) on day 5 for the whole night, i.e., blood sugars were above range for more than 8 hours.

RESULT

It can be seen that 1 night of hyperglycaemic event significantly increased the mean blood sugar for day and the week. Although the increase in mean blood sugar for 1 month can be considered minor, it is still noticeable. It can also be noted that there is an increase in mean blood sugar of 3 months. The effect of 1 hyperglycaemic event in 3 months has negligible effect on the mean blood sugar.

CONCLUSION

It can be concluded that upon analysis, singular outstanding events in the life of type 1 diabetic over a period of 3 months may not affect the mean blood sugar significantly. It can also be concluded that it is important for type 1 diabetics to have a better weekly Mean Blood Sugar to have a good 3 monthly average.

LIMITATION

The study does not take into account the number of hyperglycaemic events occurred in the period of 3 months and if they have any impact on the mean blood sugar. It should also be noted that the patient in this case did not go through a hyperglycaemic event every week or every month.

FUTURE WORK

In the future, the impact of such hyperglycaemic events can be studied in depth by including the other data like impact on vital organs of the body.
Similar study over a period of year depicting the change in the body of an adult diabetic due to hyperglycaemic and hypoglycaemic episodes can be studied and researched upon.