Exercise and Glucose Levels in Diabetes

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Dataset: T1DEXI

Types of Exercise:

Resistance
Aerobic
Interval

Analyzing the impact of different types of exercises on Glucose levels

- Finding correlations between Heart Rate, Step Count, and Glucose levels.
- Taking into account meal intakes and times of day

Endgoal of gaining more knowledge on how exercise can be done in the safest manner by people with T1D

Finding Relations Between Different Types of Exercise / Meals and Glucose Levels in Persons With Type 1 Diabetes

Early October

Data Checking

- Confirm patient-entered data via Heart Rate, and compare with Step Count
- Look for outliers, investigate possible reasons

Mid November

Data Analysis

- Use different regressors
- Use Step Count and Heart Rate both, and include meal and snack intakes
- Make models where statistically significant

Mid December

Assessing Results

- Try substantiating found correlations with known data
- Compare effects of the 3 different types of exercise, and meals

Dataset: T1Dexi

Types of Exercise:

1. Aerobic
2. Resistance
3. HIIT

Factors:

- Meals
- Insulin
- Time intervals

Initial Observations and Methods

Covariates

Heart Rate	Step Count	Glucose
Area Under Curve of HR (bpm x min)	Sum	Minimum Glucose Excursion (mg/dL)
% Max Heart Rate Reached	Area Under Curve (min)	Area Under Curve of CGM (mg/dL x min)
Maximum HR Excursion (bpm)		Peak negative values (mg/dL)
Average HR (bpm)	• Both are very similar with slight horizontal shift	

Preliminary Analysis of Covariates

Heart Rate:

- AUC gave most statistically significant results, with Average being the second best
- % Max and Max Excursion showed possibilities of short-timed spikes which were not representative of the general trends in the data

Step Count:

- Overall, it showed significantly more correlation than Heart Rate
- It could prove exercise as the only factor for increased sum of Step Counts, instead of natural externalities like high HR

Impact of Meals

Minimum Glucose Excursion could only be used when no meal or snack was taken.

For instances where meals had been recently taken, Glucose levels rose instead of dropping, and disturbed the trends being made.

With meal, a different question was to be asked:

➔ How much difference does it make if the snack is taken before or during the physical activity? (The 2 measurements we had were intake during the activity and in the 1 hour period before the activity)

Questions about Time of Day

Even in certain instances without a meal in the previous one hour, there were rises in Glucose levels, which seemed to also have a possible correlation with time of day.

- ➔ Could be because of meal intake more than 1 hour before the activity which was still leading to increased Glucose levels.

- ➔ Other natural cycles of digestion in sleep

Research Questions

1. When no meal is taken, how do the different types of exercise differently dictate the decrease in Glucose levels in people with Diabetes?

2. When a meal or snack is taken, is it recommended to take it before the exercise than during it, or do they give similar results?

3. Does the time of day during which the exercise is done have an effect on the Glucose levels of the person?

Data Analysis

Question 1

Impact of Type of Exercise

Limits set:

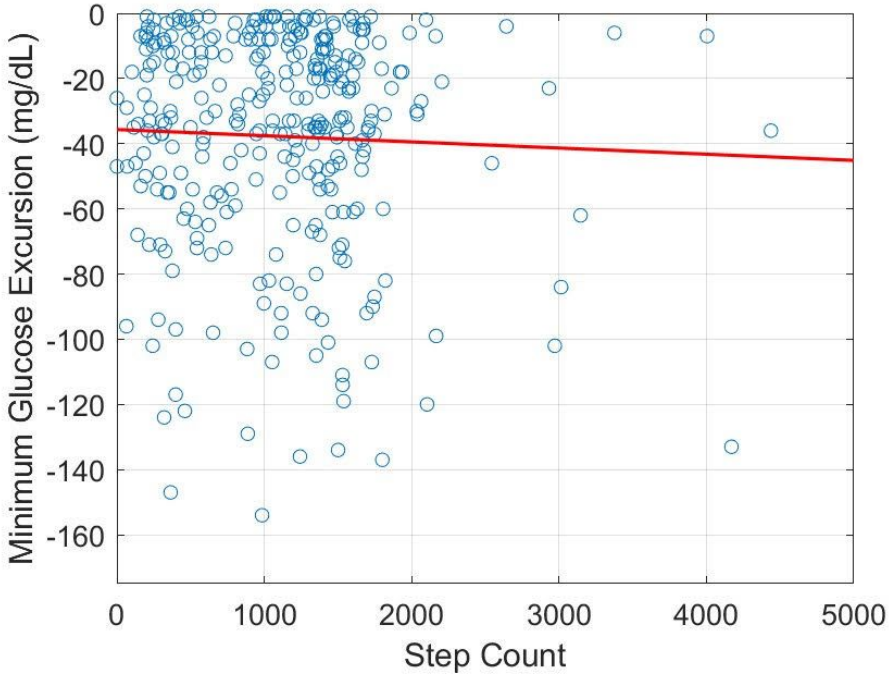
- No meal before exercise
- No snack before exercise
- No snack during activity
- There was a negative change in CGM levels

These ensured that we saw the Glucose go down as a result of the activity alone

Even without meals, some glucose measurements did not decrease, but most did

There was a negative correlation of **-0.1** found when plotting Delta CGM with Step Count, but its p-value was not significant (0.5). This was because the different types of exercises were being combined into one although they brought significantly different changes

# of Exercises: 328
# of People: 60



Why the 2 different sets of plots?

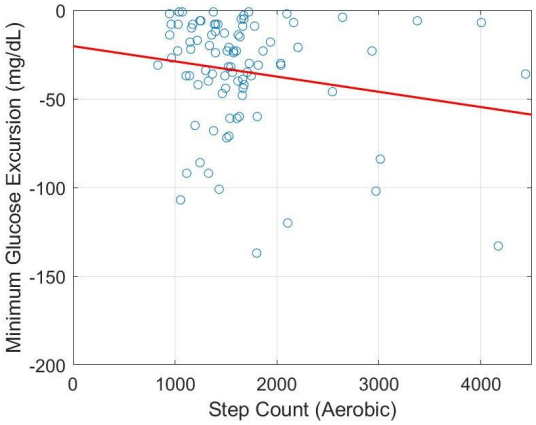
Why different plots?

It makes sense that Step Count showed a correlation for Aerobic Exercise but AUC of HR did for Resistance, since resistance exercise does not need many steps but the heart rate rises more.

Eventually, they both showed a very similar negative correlation of around -0.2

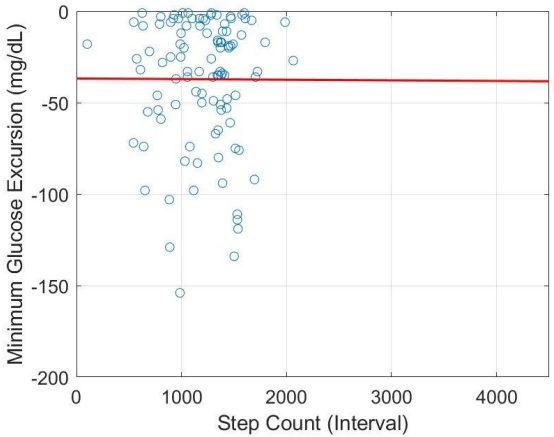
Step Count with Delta CGM

Aerobic
90 exercises by 15 people



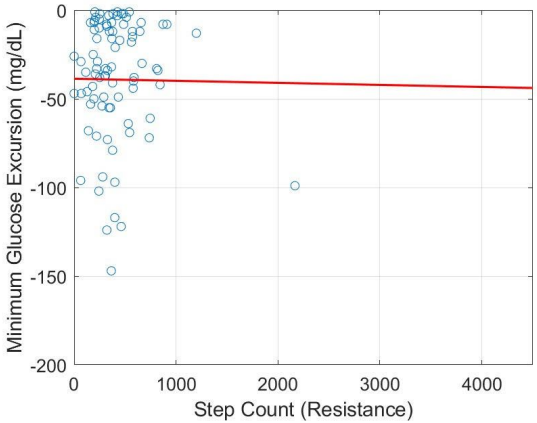
Aerobic showed a negative correlation of -0.18, with a statistical significance of 0.01

Interval
103 exercises by 19 people



Correlation: -0.03
P-value: 0.97

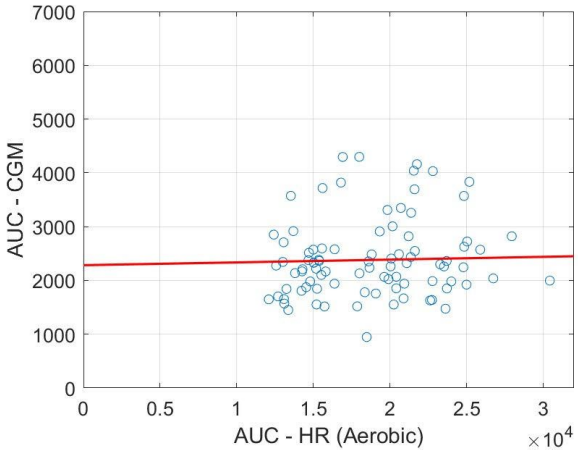
Resistance
87 exercises by 16 people



Correlation: -0.08
P-value: 0.9

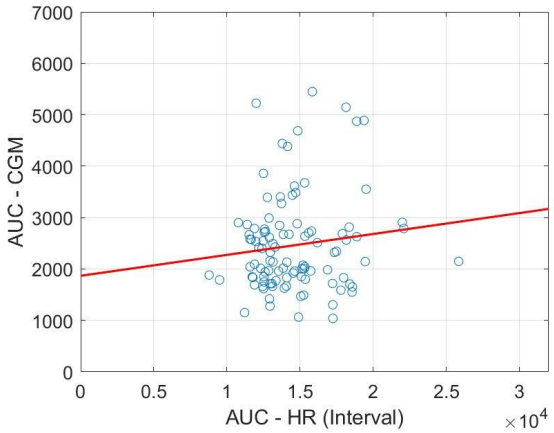
AUC of Heart Rate with AUC of CGM

Aerobic
90 exercises by 15 people



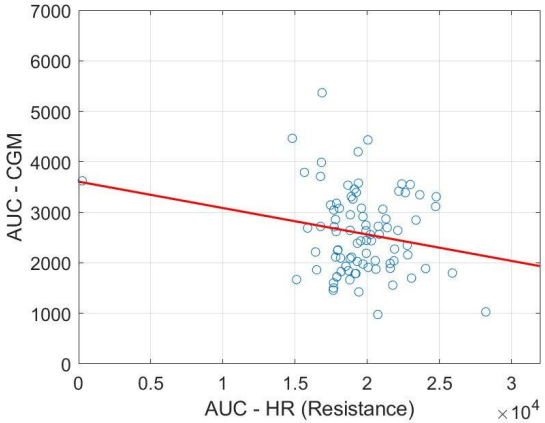
Correlation: 0.03
P-value: 0.75

Interval
103 exercises by 19 people



Correlation: 0.12
P-value: 0.22

Resistance
87 exercises by 16 people



Resistance showed a negative correlation of -0.2, with a statistical significance of 0.01

Discussion

Interval exercise did not show any significant drop or rise in glucose as the step count or heart rate integral increased, showing that it is the safest to do without having had a meal if dropping glucose levels is an issue

Aerobic and Resistance showed significant correlations of -0.18 and -0.2 when plotted against Step Count and AUC of HR respectively, showing that they led to a greater decrease in Glucose levels as compared to Interval exercises.

WHY?

Could be because of the breaks in interval activities which could require less breakdown of carbohydrates.

Question 2

Impact of meal/snack intake

Meal intake timings

Plotted two different data sets:

1. Meal/snack taken in the 1 hour period before the exercise
2. Snack taken during physical activity

Evaluation Metrics:

- Average initial Glucose (mg/dL)
- Average change in Glucose (mg/dL)
- % time in range (70 - 180 mg/dL), time above 180 mg/dL, and time below 70 mg/dL
- % of exercises in which the person went or did not go below 70 mg/dL
- % of exercises in which the person went or did not go above 180 mg/dL
- Ratio of exercise sessions with negative or positive change in glucose

Results

	Total # of Exercises / People	Average Initial glucose (mg/dL)	Average Change in glucose (mg/dL)	Ratio of number of negative change vs positive change in Glucose	% Who dropped below 70 mg/dL	% Who rose above 180 mg/dL	Average % Time in Range (70-180 mg/dL)	Average % Time below 70 mg/dL	Average % Time above 180 mg/dL
Meal/snack consumed 1 hour before exercise	527/94	136 +- 48 mg/dL	-19.4 +- 59 mg/dL	4.00 (423/104)	16.5%	40.4%	80.2%	3.6%	16.1%
Snack consumed during exercise	69/10	122 +- 39 mg/dL	-24.8 +- 70 mg/dL	4.75 (57/12)	40.6%	31.9%	81.1%	8.8%	10.1%

Discussion

- ➢ The CGM of only 16.5% of people who had consumed a meal or snack before the activity went under 70, whereas for the other 83.5 %, their CGM never dropped below 70 mg/dL.
- ➢ A much larger 40.6% of exercises with snacks consumed during the activity went under 70 mg/dL.
- ➢ Average change in CGM was 5.4 units less for those who had consumed before activity
- ➢ Time in Range was very similar, because those who had consumed before often went above 180 units

- ★ If time below 70 mg/dL is to be avoided, a meal in the 1 hour period before the exercise is suggested over a snack during the activity itself

Question 3

Impact of time of day

Time of Day Variables

Morning: 3 AM - 12 PM

Afternoon: 12 PM - 6 PM

Evening: 6 PM - 3 AM

Limits: No meal/snack 1 hour before exercise

- This was to decrease the amount of factors affecting the Glucose level while analyzing the effect of time of day

➔ Evaluation metrics similar to those in the meal analyses

Results

	Total # of Exercises / People	Average Initial glucose (mg/dL)	Average Change in glucose (mg/dL)	Ratio of number of negative change vs positive change in Glucose	Average % Time in Range (70-180 mg/dL)	Average % Time below 70 mg/dL	Average % Time above 180 mg/dL
Morning (3 AM - 12 PM)	55/7	146 +- 71 mg/dL	-17 +- 55 mg/dL	5.1 46/9	77.8 %	3.0 %	19.3 %
Afternoon (12 PM - 6 PM)	77/14	142 +- 48 mg/dL	-14 +- 61 mg/dL	4.1 62/15	71.6 %	2.4 %	25.9%
Evening (6 PM - 3 AM)	233/35	138 +- 58 mg/dL	-4 +- 69 mg/dL	2.8 172/61	71.7 %	3.8 %	24.4 %

Discussion

Conducted an Analysis of Variance (ANOVA) of:

- the % Time in Range between the 3 times of day
- Average Max/Min Excursion of Glucose

	F-ratio value	p-value
% TIR	0.79	0.45
Average Change	1.30	0.27

The value for %TIR is less than 1, meaning that the difference between average % of time in range (70 - 180 mg/dL) in morning, afternoon and evening exercises is negligible, given that the p-value is high as well.

Especially between afternoon and evening sessions, the difference between the average % time in range is **only 0.1 %**.

Morning exercises show a **6.15 % higher** average time in range than the other two time periods.

- This difference is mainly due to an increase % of time ABOVE 180 mg/dL rather than more time below 70 mg/dL

The results show that it is more recommended to exercise in the morning to maintain the Glucose levels between 70 and 180 mg/dL for the highest percentage of time

Discussion

The f-ratio value for Average Change in Glucose (Delta) is slightly higher than 1, indicating that there is slightly more variation in that, although the p-value is still insignificant.

Morning exercise sessions show the greatest average negative change in Glucose (-17 mg/dL), followed by afternoon (-14 mg/dL), and evening sessions have the smallest average change of -4 mg/dL.

- This is also counteracted by the fact that the average initial starting Glucose levels also drop proportionally, from 146 to 142 to 138 mg/dL.

Notes for Future

Meal - type of exercise?

Pairwise function

Time UTC Offset