

# Using CGM to Improve Outcomes

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**JDRF** IMPROVING  
LIVES.  
CURING  
TYPE 1  
DIABETES.

# Making the Most of Continuous Glucose Monitoring

1. CGM Basics
2. Real-Time Use
3. Analyzing Downloaded Data

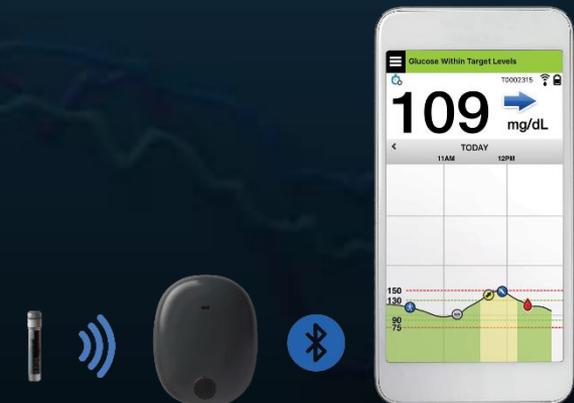
# CGM Options

## “Personal” CGM

- DexCom G6
- Medtronic Guardian (670G / Connect)
- Freestyle Libre
- Senseonics Eversense

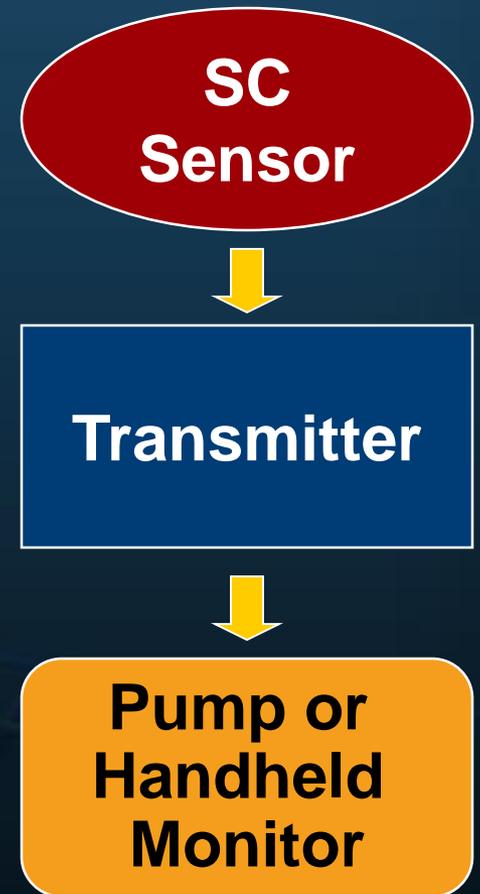
## “Professional” CGM

- Medtronic iPro
- Dexcom G4 Professional
- Freestyle Libre Pro

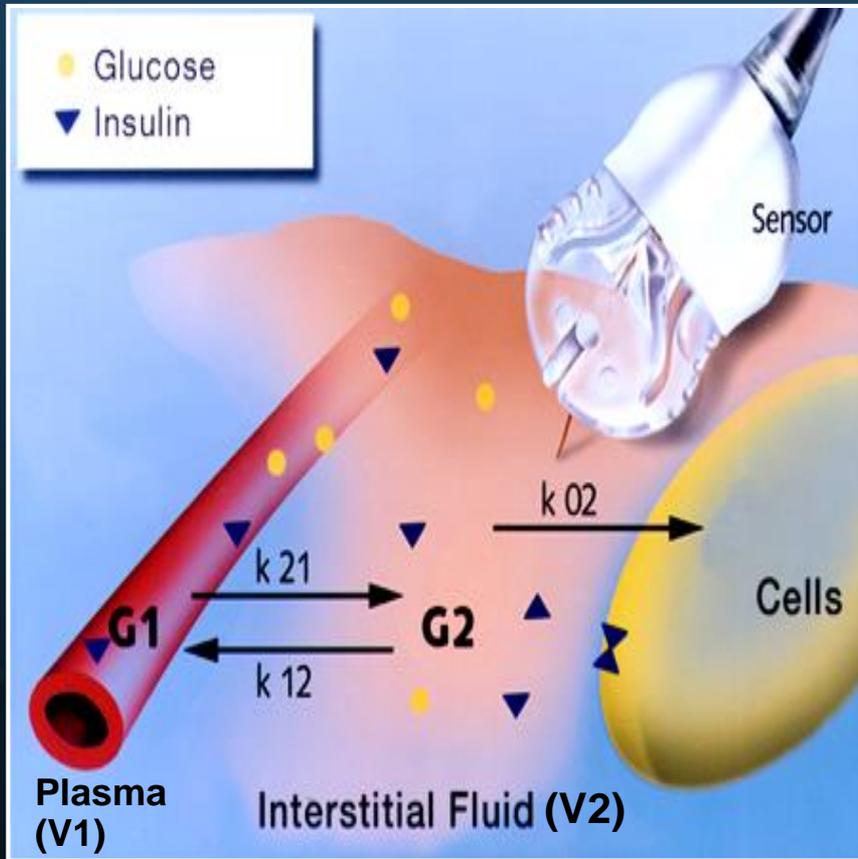


# How They Work

- Glucose sensor is inserted in subcutaneous tissue and connected to a transmitter
- Glucose sensor sends values to the transmitter
- Transmitter then sends data wirelessly to a phone, watch, pump or handheld monitor where data can be viewed and acted upon in real-time

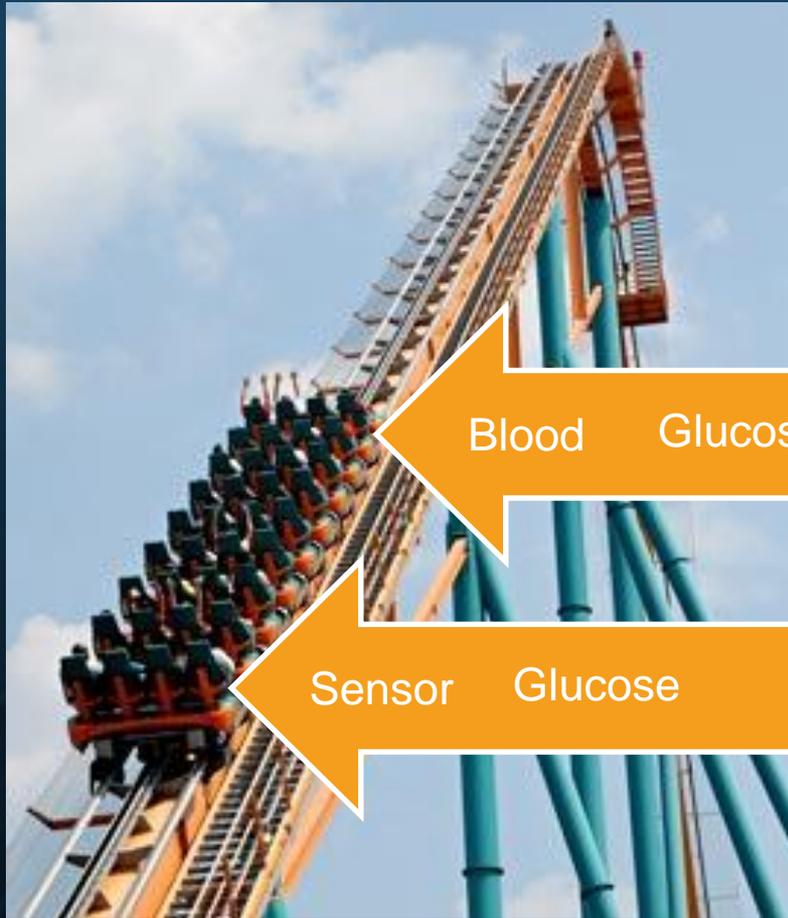


# Interstitial Fluid and “Lag Time”



- Capillary glucose must diffuse into the interstitial fluid (ISF)
- ISF glucose levels may lag capillary levels by 5–15 minutes
- When glucose levels are stable, ISF glucose levels and capillary blood glucose levels are similar
- Overall, the sensor glucose trends are more important than the absolute measurements

# Understanding Lag Time



**Glucose Rising:**

SG likely lower than actual BG

# Understanding Lag Time



Sensor Glucose

**Glucose Falling:**

SG likely higher than actual BG

Blood Glucose

# Understanding Lag Time

Glucose Stable:

SG likely in equilibrium with BG



# Understanding Lag Time

**During Exercise:**  
Lag Time is extended.



**Aerobic exercise:**  
CGM tends to over-estimate glucose

**Anaerobic/HIIT exercise:**  
CGM tends to under-estimate glucose

# Clinical Advantages of CGM

- ❖ Reduction in HbA1c
- ❖ Less glycemic variability
- ❖ Increased time in-range
- ❖ Reduced hypoglycemia
  - ❖ Frequency
  - ❖ Severity
  - ❖ Duration
- ❖ Permits true pattern analysis

*Diabetes Care* 2010;33:17-22

*Diabetes Care* 2013;36(12):4160-4162

*JAMA* 2017;317(4):371-378

*JAMA* 2017;317(4):379-387

# Quality of Life Advantages

- ❖ ↓↓↓ SMBG Requirements
- ❖ Real-time data sharing
- ❖ Overnight peace of mind
- ❖ Enhanced safety
  - ❖ Driving
  - ❖ Sports/Exercise
  - ❖ Hazard Situations
- ❖ Learn cause:effect relationships
- ❖ Drive hybrid closed-loop technology





# The Numbers: How Accurate Are They Really?

## MARD Compared to YSI(lab)

**Freestyle Libre<sup>1</sup>: 11.4%**

Older popular meters<sup>5</sup>: 10-11%

**Medtronic Guardian<sup>2</sup>: 10.6%**

**Dexcom G6<sup>3</sup>: 9.9%**

**Senseonics™ Eversense<sup>4</sup>: 8.8%**

**State-of-the-art BG Meters<sup>5</sup>: 4-6%**

1 Wadwa et al. Diab Tech & Ther, 20:6, 2018 (0 cal/day)

2 FDA SSED P160017/S017, 2/13/2018 (2 cal/day)

3 Bailey et al. Diab Tech & Ther, 17:11, 2015 (0 cal/day)

4 PRECISE II: Diab Tech & Ther, 20:3, 2018 (2 cal/day)

# Can The Numbers Be Trusted?

**Two years ago, 81%  
of CGM Users openly  
admitted to using  
CGM glucose values  
for determining insulin  
doses.\***

# Can The Numbers Be Trusted?

**YES.** but...

- Not if a CGM novice
- Not during sensor day 1\*
- Not when recovering from hypoglycemia
- Not in state of rapid rise or fall
- Not if recent calibration off >20%
- Not if acetaminophen taken in past 4 hrs\*
- Not if symptoms don't match SG value

\* Not applicable to Dexcom G6

# ≡ Alerts ≡



# Types of Alerts

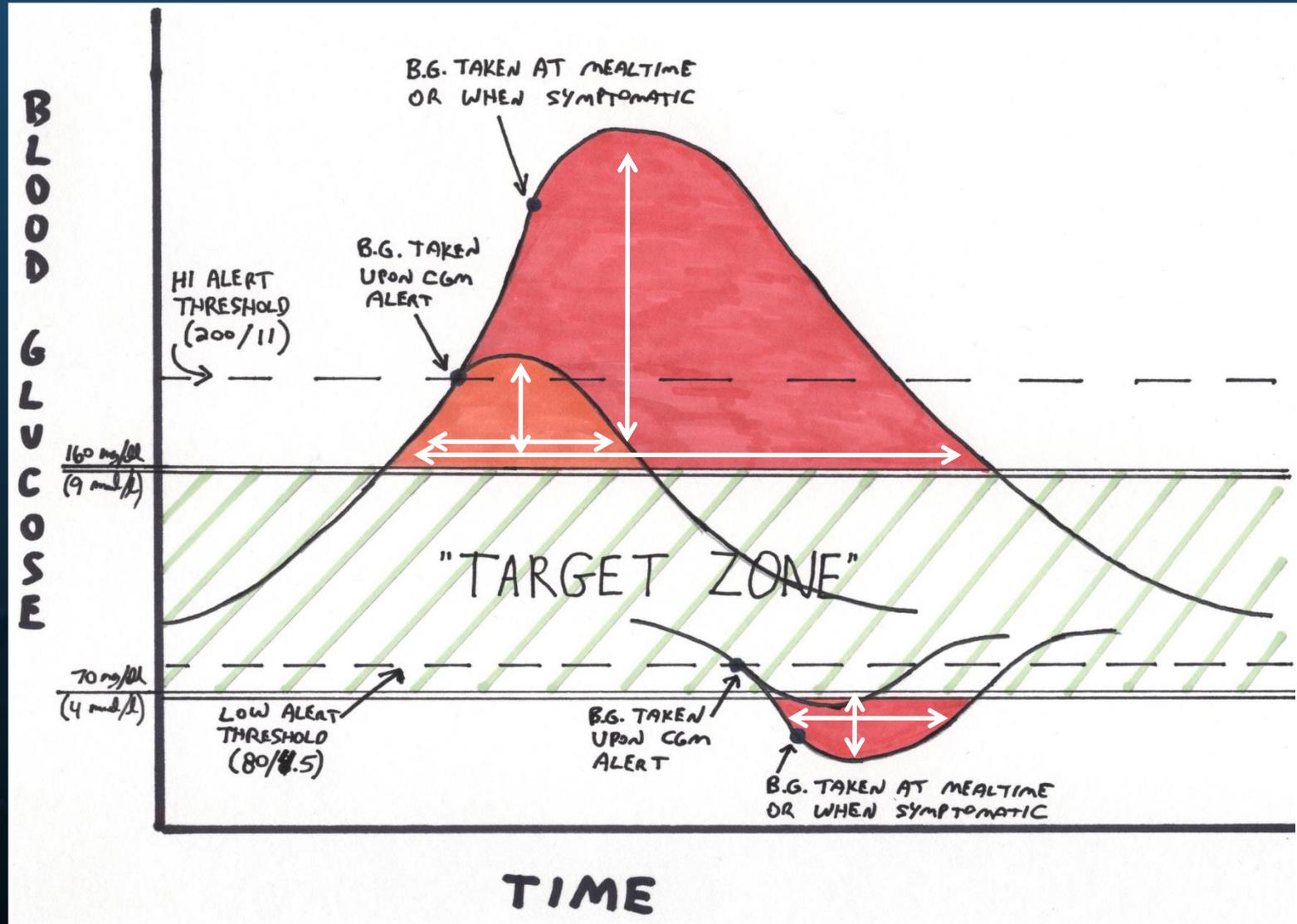
- **Hi/Low Alert:** Cross specified high or low thresholds
- **Predictive Alert:** *Anticipated* crossing of high or low thresholds
- **Rate of Change:** Rapid rise or fall

- **Hi/Low Alert:**
  - ✓ must balance benefit vs nuisance
  - ✓ low:  $\geq 80$  mg/dl
  - ✓ high: start very high (300?), titrate down to allowable postprandial peak
- **Predictive Alert:**
  - ✓ potential for false positives
  - ✓ set for short time interval ( $\leq 10$  min)
- **Rate of Change:**
  - ✓  $>3$  mg/dl/min fall rate (for preventing lows)
  - ✓  $>3$  mg/dl/min rise rate (for missed boluses)

# The Value of Alerts:

## Minimizing the DURATION and MAGNITUDE of BG Excursions

# CGM Turns Mountains into Molehills



# CGM Alerts Are Like BLOOD SUGAR BUMPERS!



# Timely, consistent response is Key!



1. Act on the highs
  - hydrate
  - exercise
  - bolus (less IOB)
2. Act on the lows
  - rapid carbs

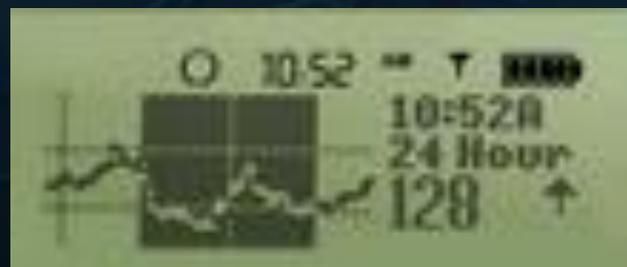
# Decision-Making Based on Trend Information

- **Self-Care Choices**

- To snack?
- To check again soon?
- To exercise?
- To adjust insulin?

- **Key Situations**

- Driving
- Sports
- Tests
- Bedtime



# Adjust Boluses Based on Arrows



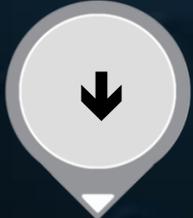
**Add enough to offset 75 mg/dl rise**



**Add enough to offset 50 mg/dl rise**



**Add or subtract enough to offset 25 mg/dl change**



**Subtract enough to offset 50 mg/dl drop**



**Subtract enough to offset 75 mg/dl drop**

# Simplify It With Sticky Notes!

Example:

**Correction Factor = 30**

↑↑ +2.5u

↑ +1.6u

↗ + 0.8u

↘ - 0.8u

↓ -1.6u

↓↓ -2.5u



# Answer This!

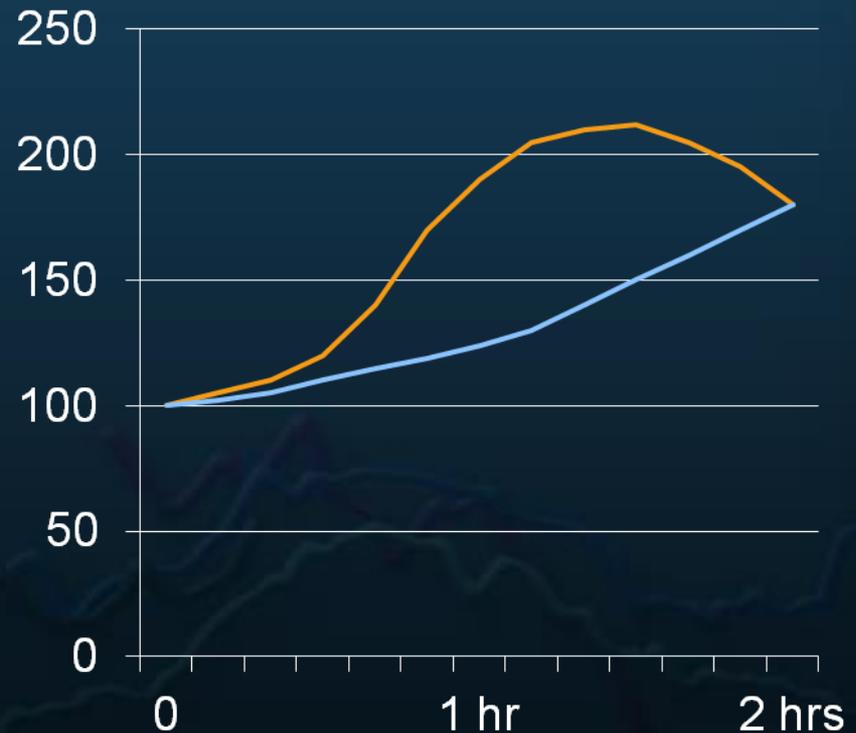
Betty Lou's blood sugar is rising going into lunch. She should:

- A. Take her usual insulin dose (based on BG and carbs)
- B. Take her usual dose, but delay her meal
- C. Take more than her usual dose

# Other Applications for Trend/Curve: Hyperglycemia Treatment:

(When the ~~level~~ trend graph breaks)

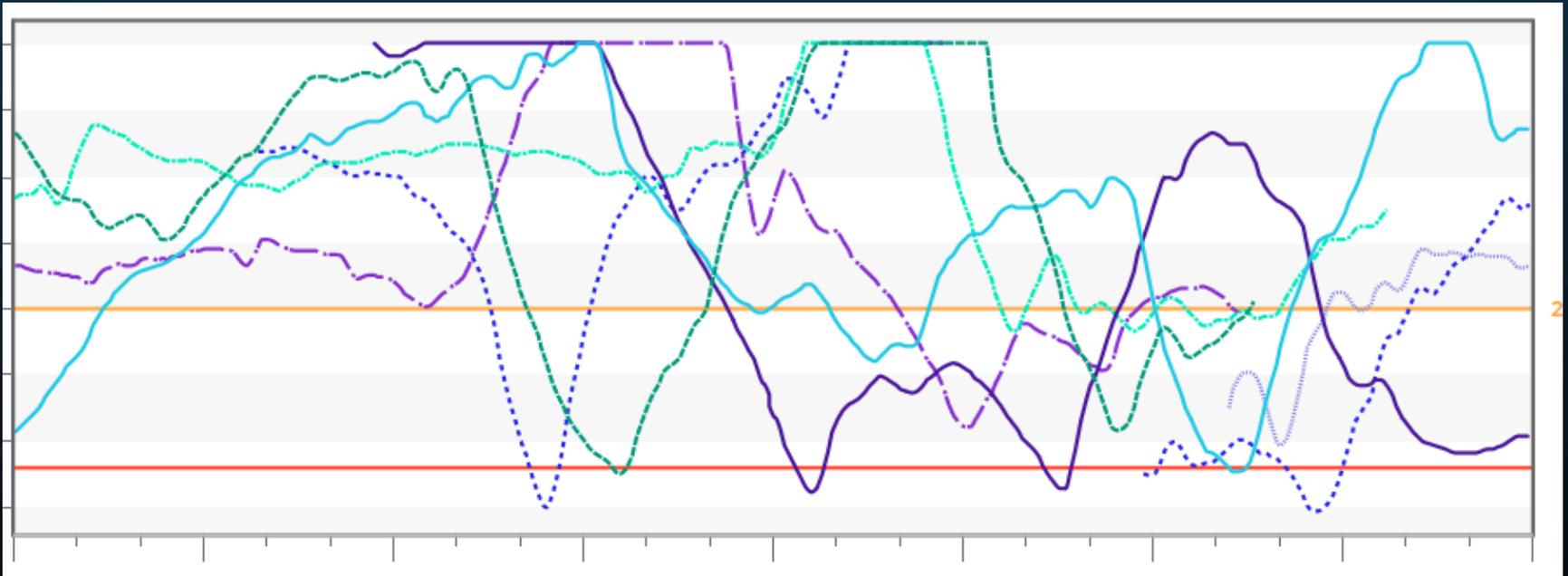
- **Break within 2 hours of bolus: do not correct!**
- **No break within 2 hours of bolus: Correct!**



# What Can We Get From Analyzing CGM Data?

*(a retrospective journey)*

**Completely  
Overwhelmed!**



# Objectives-Based Analysis

1. Are bolus amounts appropriate?
  - Meal doses
  - Correction doses
2. How long do boluses work?
3. What is the magnitude of postprandial spikes?
4. Is basal insulin holding BG steady?

# Objectives-Based Analysis

5. Are asymptomatic lows occurring?
  - Are there rebounds from lows?
  - Are lows being over/under treated?
6. How does exercise affect BG?
  - Immediate
  - Delayed effects
7. Are there day-of-the-week patterns?

# Objectives-Based Analysis

## 8. How do various lifestyle events affect BG?

- Hi-Fat meals
- Unusual foods
- Stress
- Illness
- Work/School
- Sex
- Alcohol

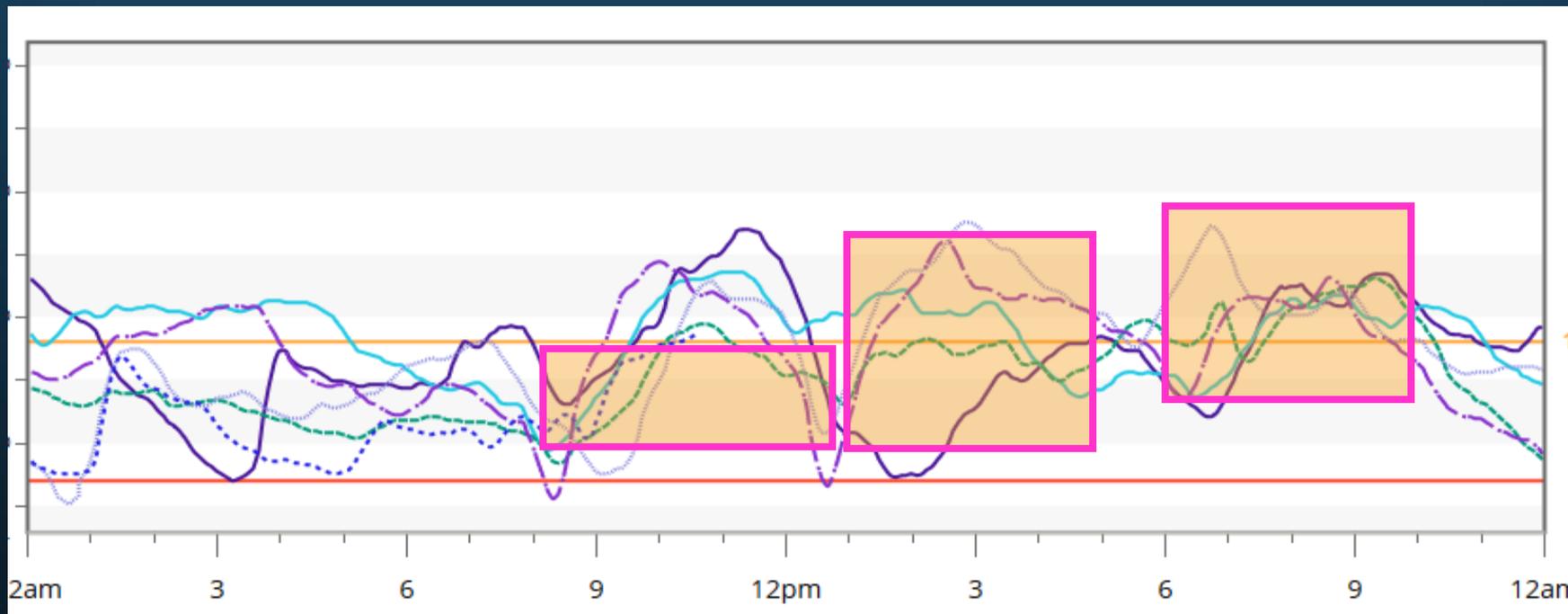
# These Are a Few of My Favorite Stats...



- ❑ Mean (avg) glucose
- ❑ % Of Time Above, Below, Within Target Range
- ❑ Standard Deviation
- ❑ # Of High & Low Excursions Per Week

# Case Study 1a: Fine-Tuning Meal/Correction Boluses

- 34-y.o. insulin pump user, applying insulin:carb ratios



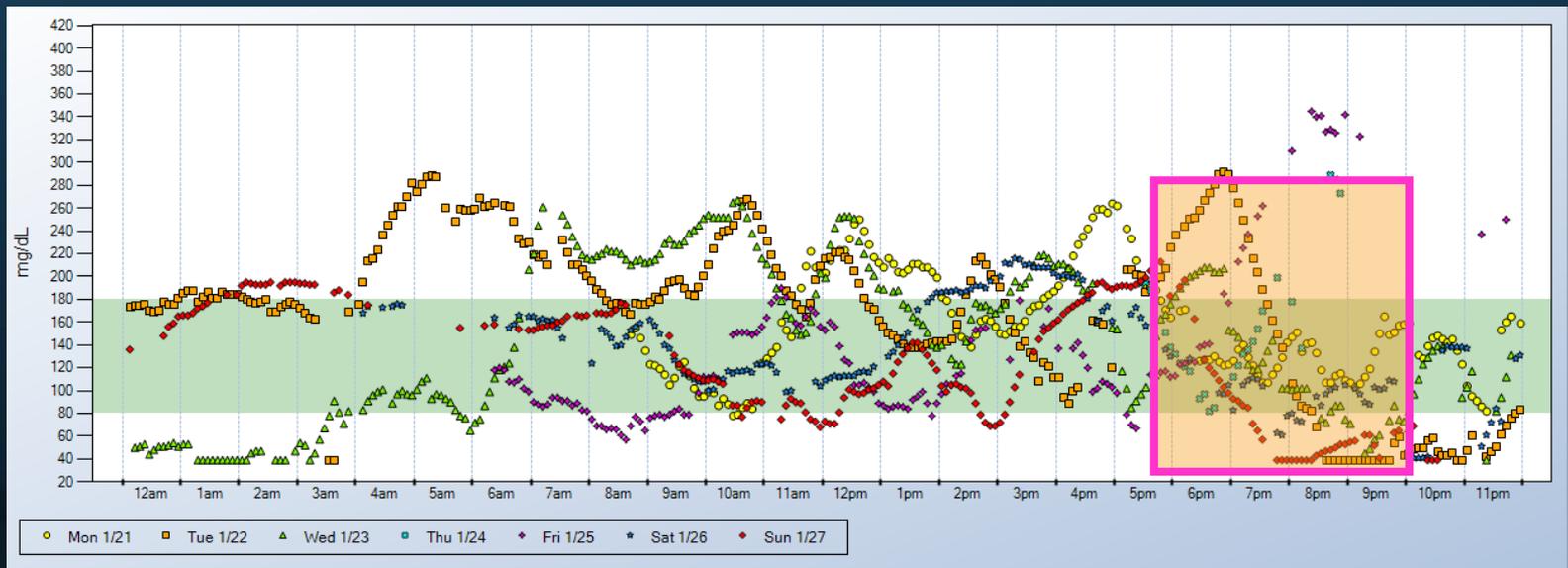
**Breakfast dose  
is sufficient**

**Lunch dose is  
insufficient**

**Dinner dose is  
insufficient**

# Case Study 1b: Fine-Tuning Meal/Correction Boluses

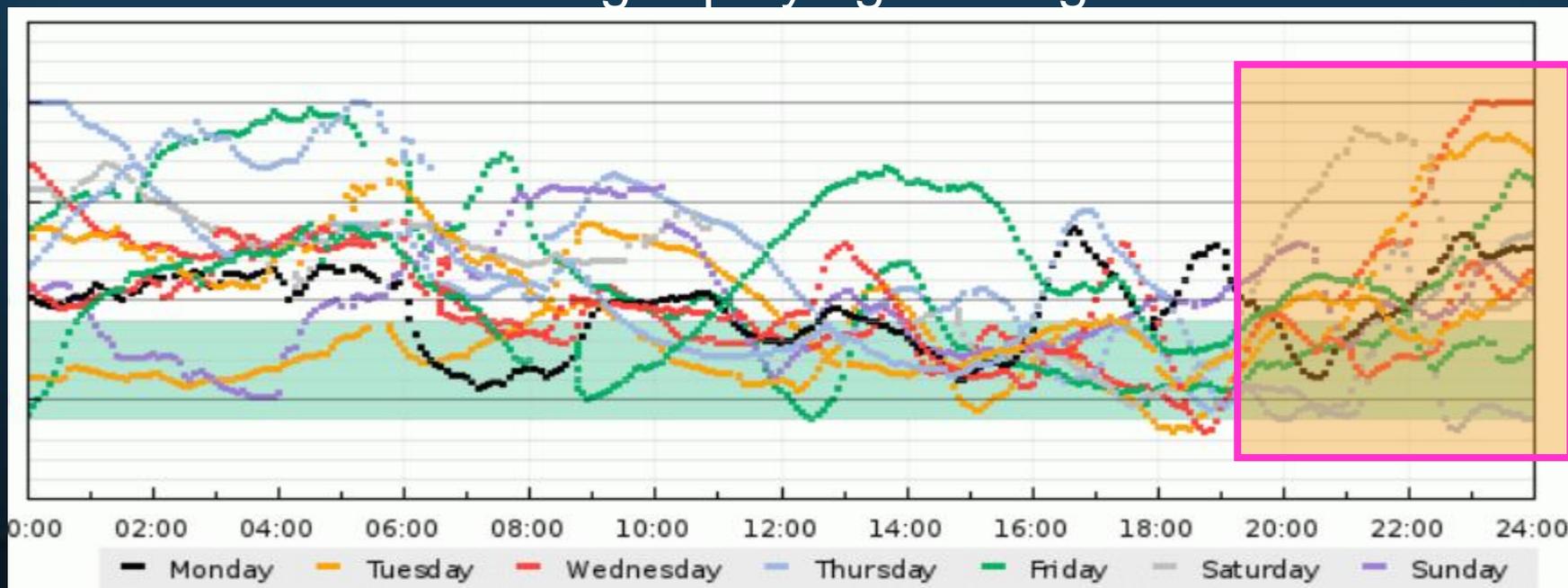
- 5-year-old on MDI; detemir BID.



**Dropping low 2-3 hours after dinner.  
Consider decreasing dinner bolus.**

# Case Study 1c: Fine-Tuning Meal/Correction Boluses

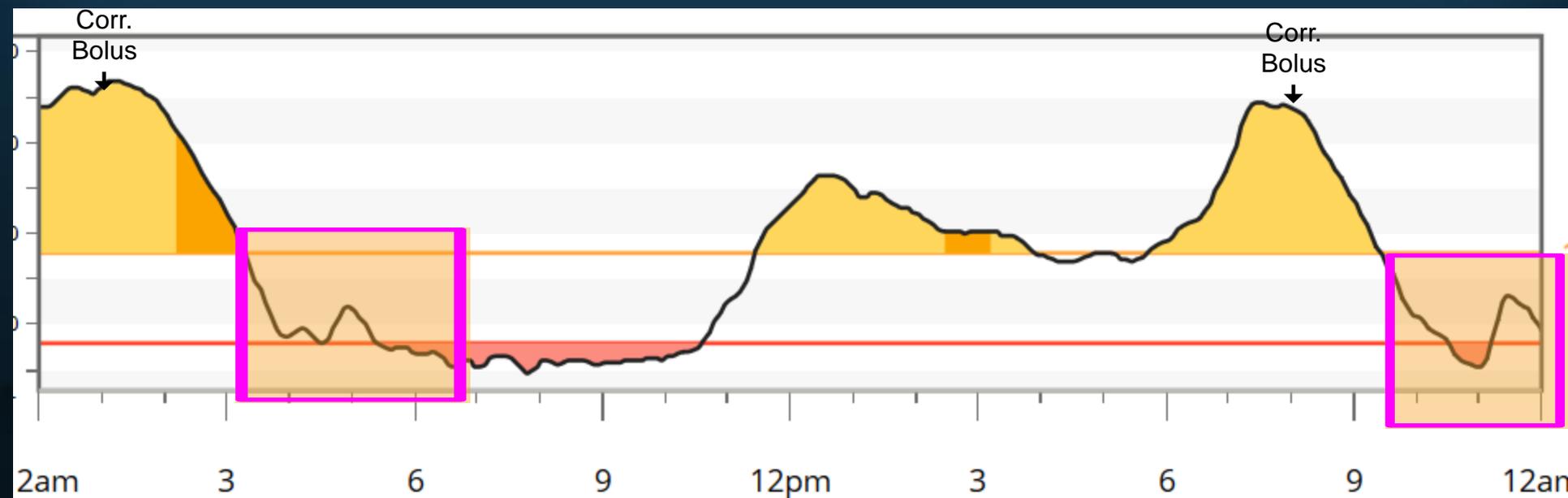
Teenager on a pump; stays up late snacking & playing video games.



**Raise I:C ratio after dinner? Work on carb counting? Structured snacks?**

# Case Study 1d: Fine-Tuning Meal/Correction Boluses

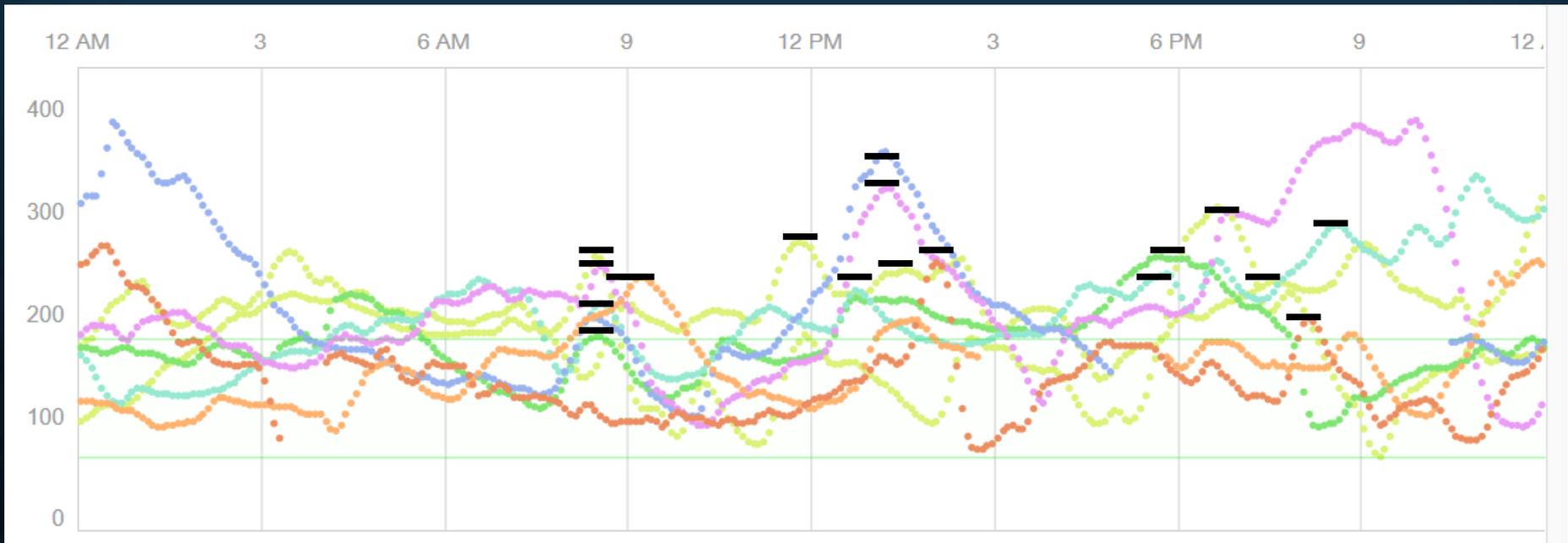
- Adult T1, detemir BID and MDI, 11% of time below target.



**Consider increasing correction factor**

# Case Study 2a: Postprandial Analysis

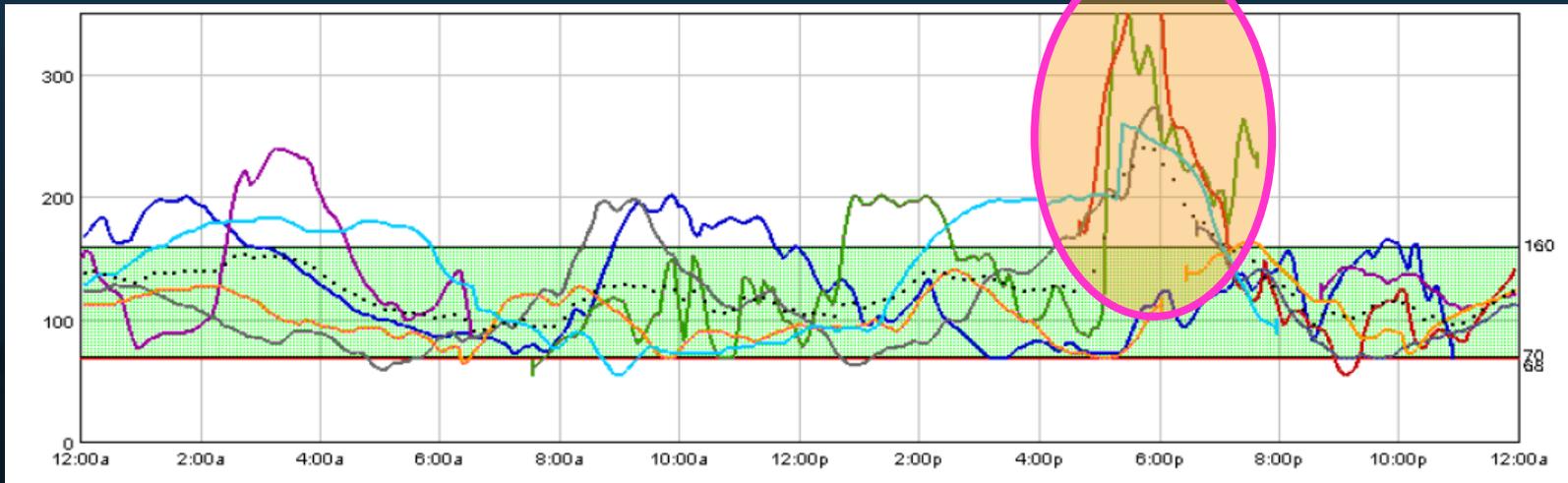
- Young adult on MDI.
- HbA1c are higher than expected based on SMBG.
- Tired and lethargic after lunch.



**Greatest “spikes” after lunch. Strategies???**

# Case Study 2b: Postprandial Analysis

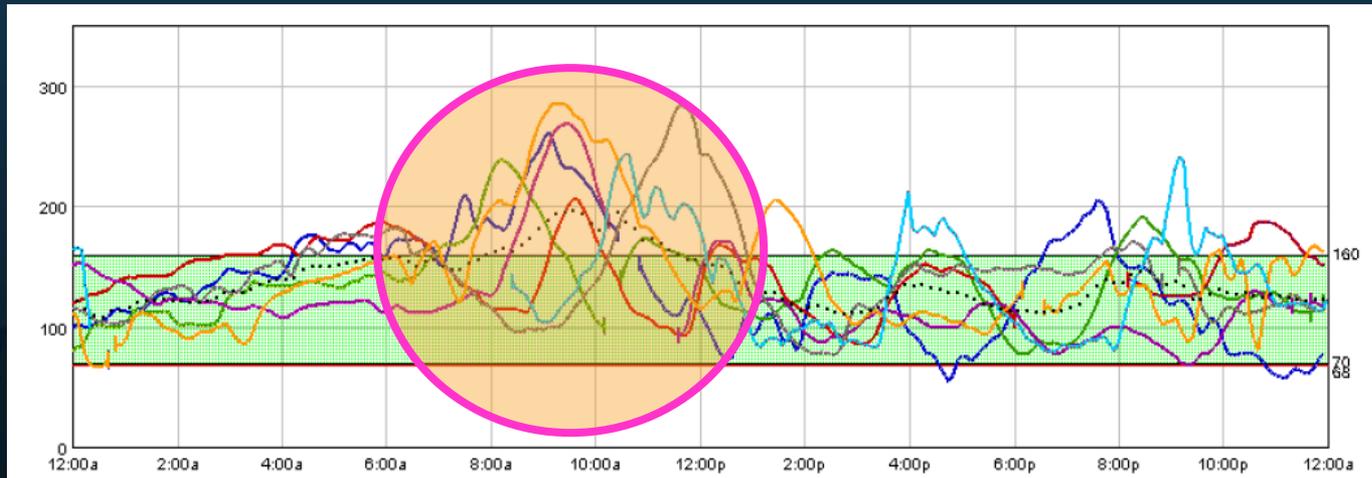
- Pump user, usually bolusing right before eating.
- Potatoes w/dinner most nights.



**Spiking primarily after dinner.  
Consider lower g.i. food or pre-bolusing.**

# Case Study 2c: Postprandial Analysis

- Pump user, 6 months pregnant
- Pre-bolusing (15-20 min) at most meals.

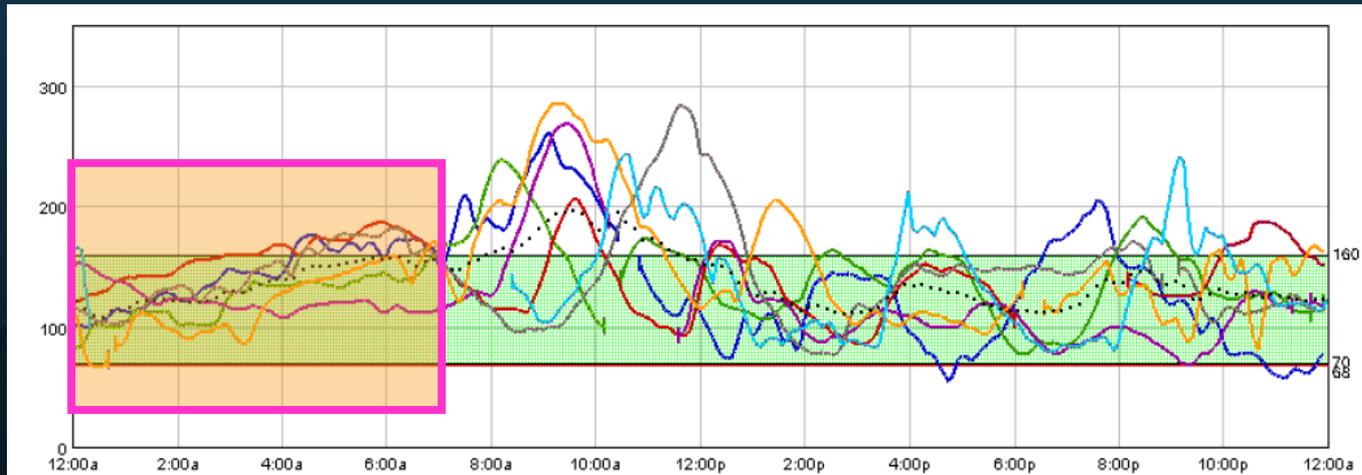


**Spiking primarily after breakfast.**

**Consider “splitting” breakfast or walking post-bkfst.**

# Case Study 3a: Basal Insulin Regulation

- Pump user, 6 months pregnant
- Generally not eating (or bolusing) after 8pm.

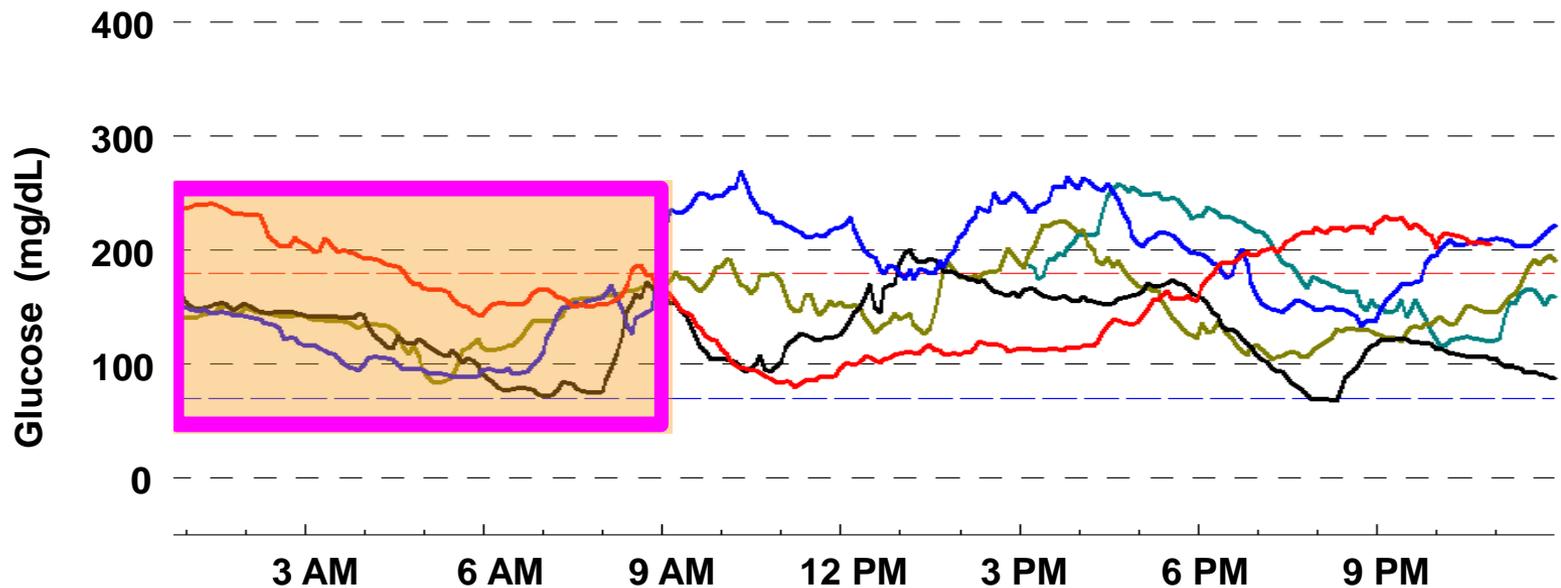


**BG rising 1am-6am.**

**Consider raising basal insulin 11pm-4am.**

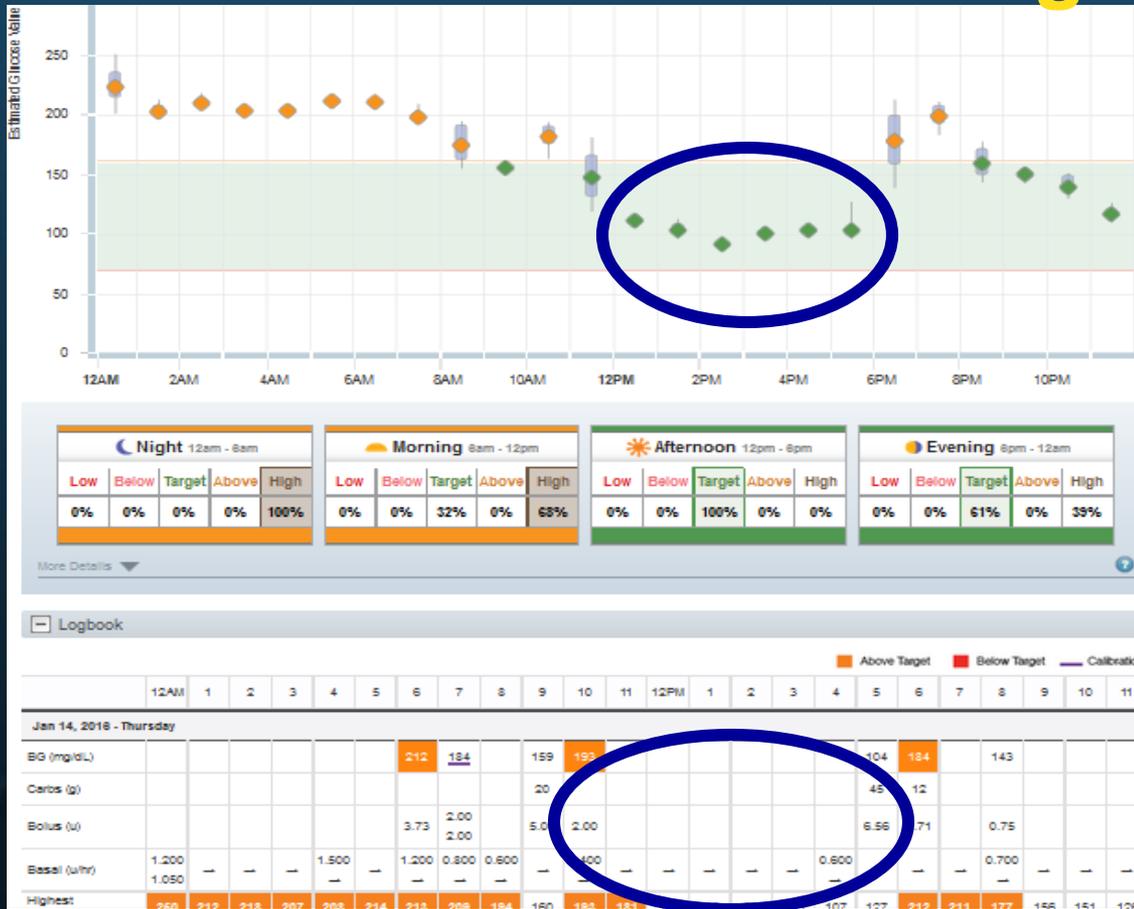
# Case Study 3b: Basal Insulin Regulation

- Type 1 diabetes; using insulin glargine & MDI
- History of morning lows
- Snacking at night and not “covering” w/bolus



**Basal dose is likely too high. Consider reducing.**

# Case Study 3c: Basal Insulin Regulation

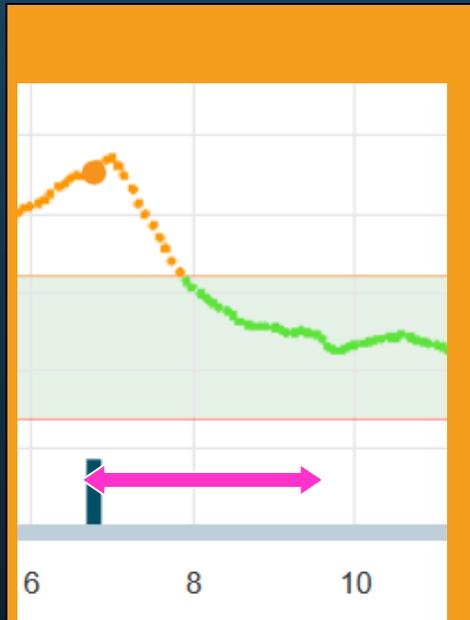


- Pump user, fasted (and no bolus) from 10am to 5pm.

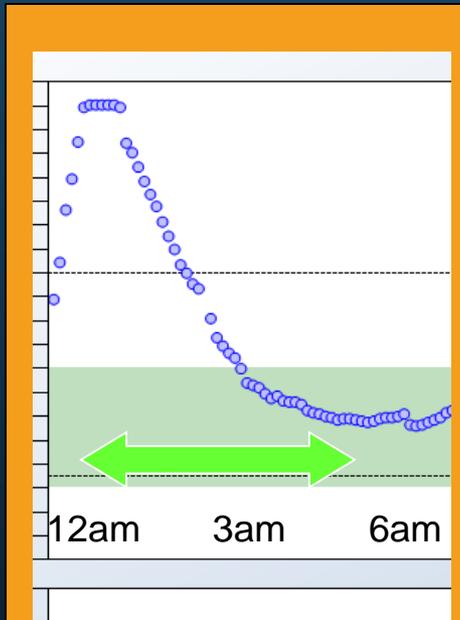
**BG stable 1pm-5pm.**

**Basal setting verified 12-4.**

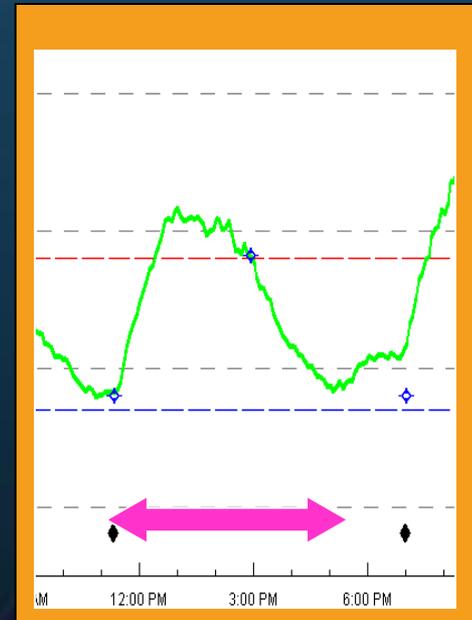
# Case Study 4a: Determination of Insulin Action Curve



**3-Hour  
Duration**



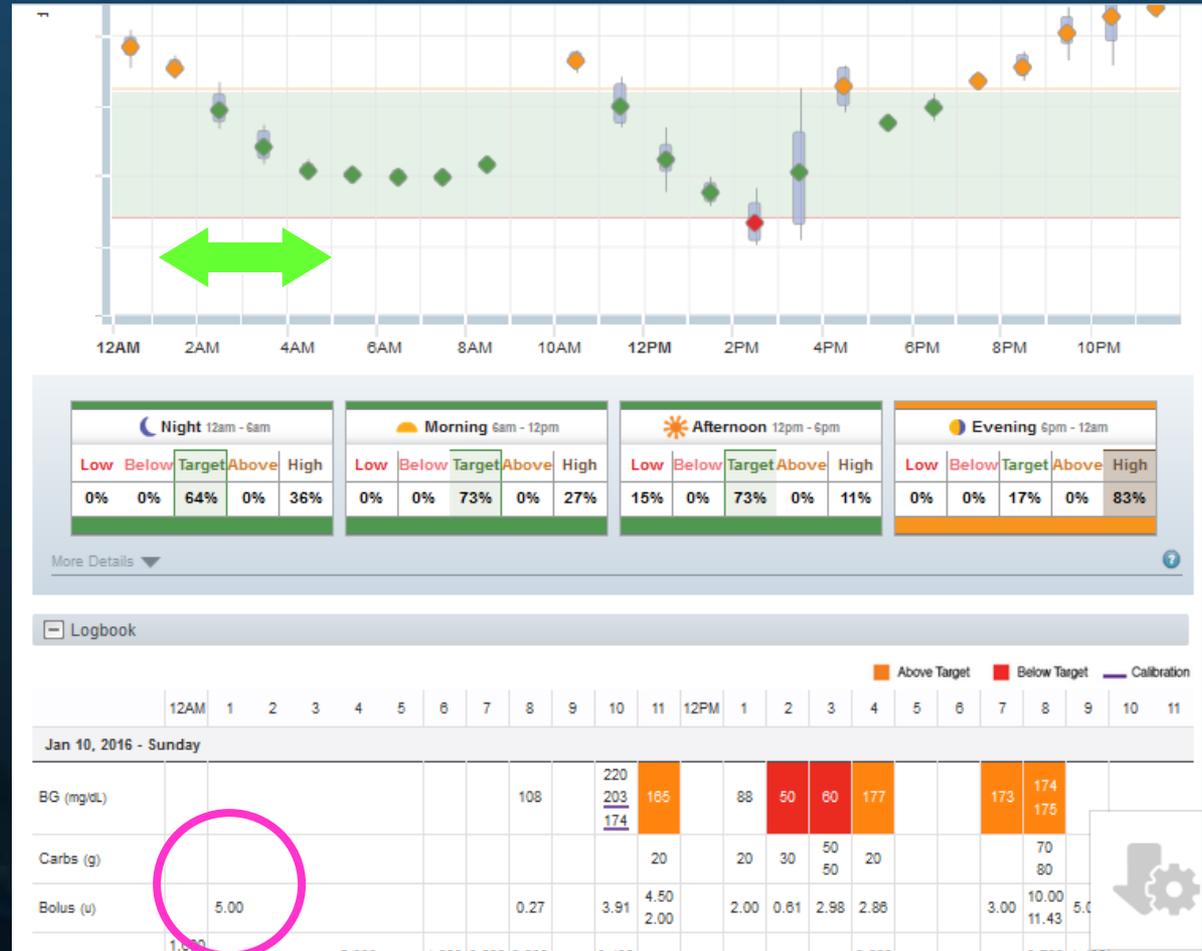
**4-Hour  
Duration**



**5-Hour  
Duration**

# Case Study 4b: Determination of Insulin Action Curve

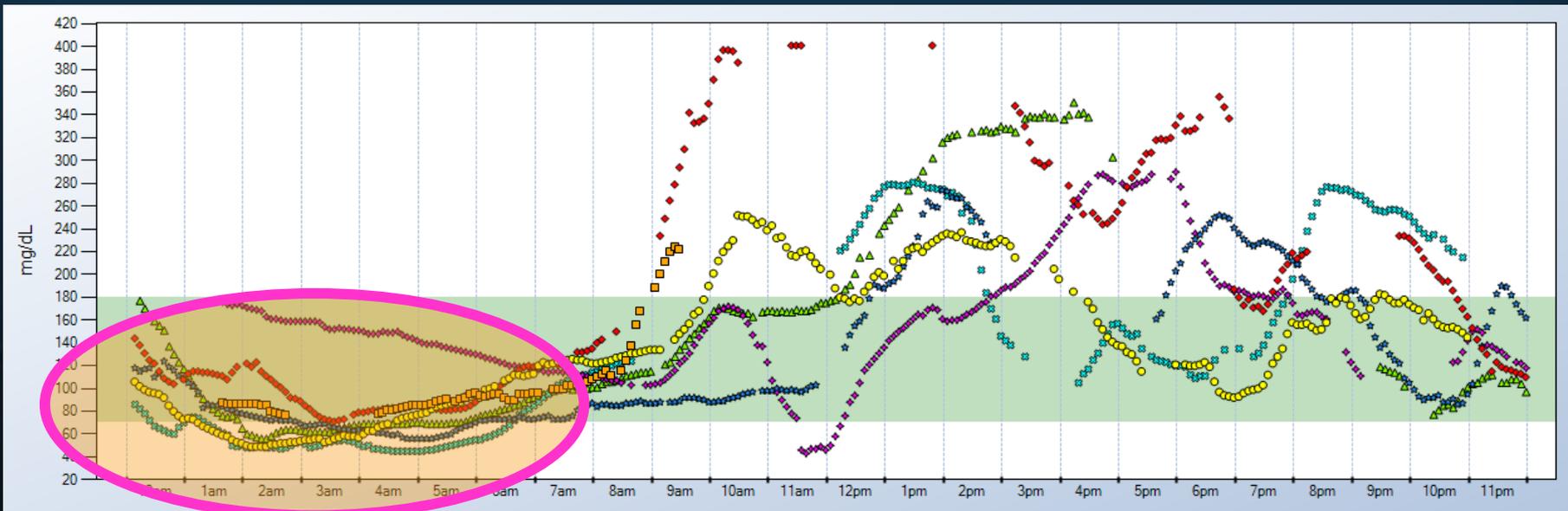
- Correction bolus at 1am
- BG levels off at 4:30 am



**3.5 Hour Duration of Bolus Action.**

# Case Study 5: Patterns Surrounding Hypoglycemia

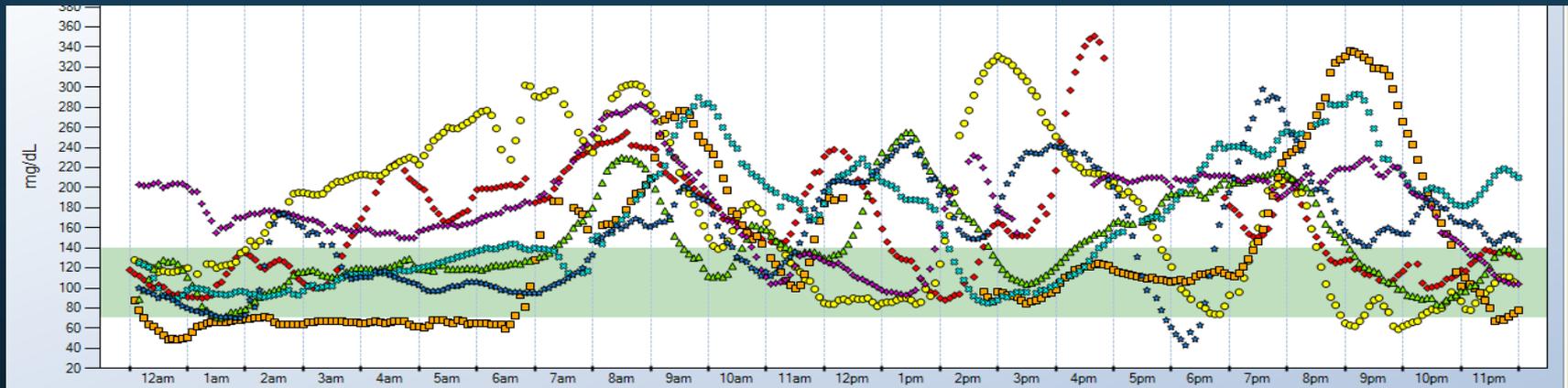
- Type 1 college student; on pump
- Frequent fasting highs (9-10 AM). Wanted to raise overnight basal rates.



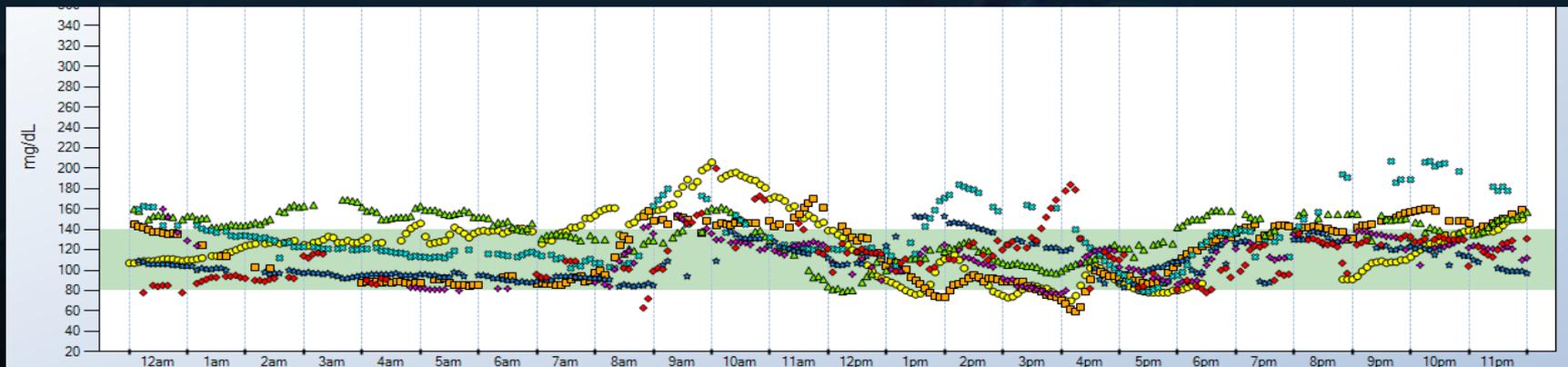
**Dropping & rebounding during the night.  
Consider decreasing basal in early part of night.**

# Case Study 6: Effectiveness of Ancillary Meds

- 6 mg liraglutide



- 12 mg liraglutide



# Case Study 7: Day-Of-The-Week Analysis



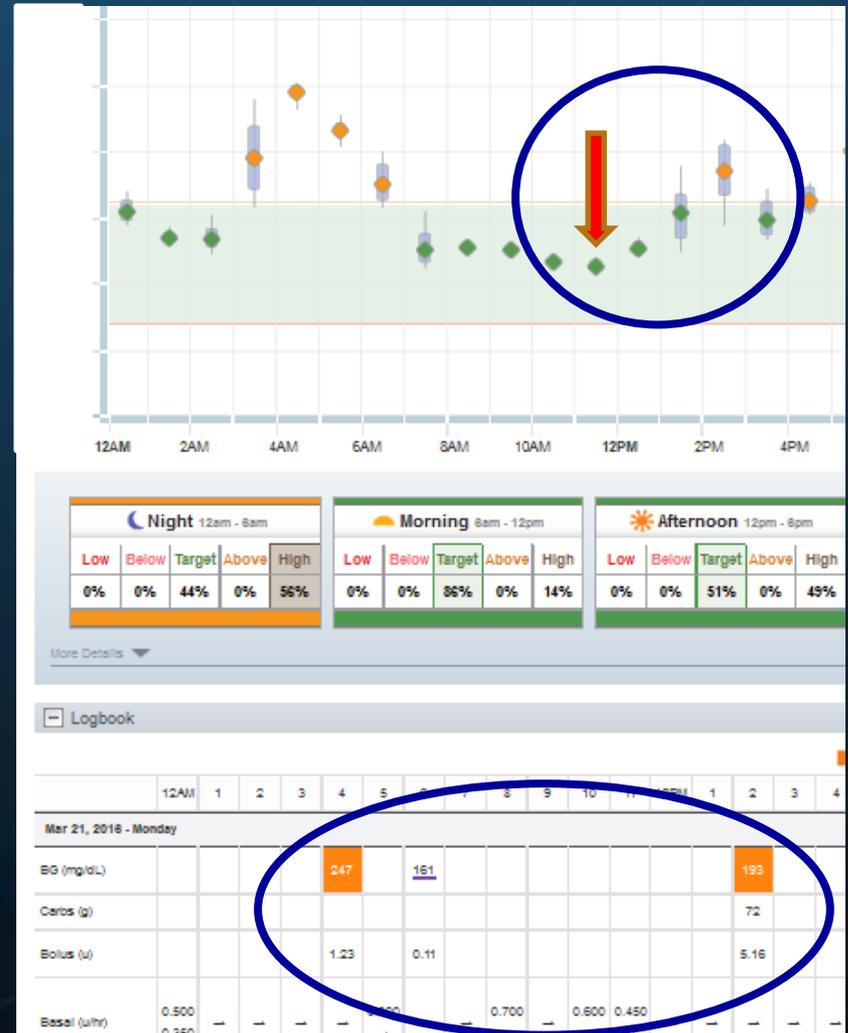
- Significantly more lows on Thursdays.

**Look for days of the week with unusual proportion of highs or lows. Ask the right questions!**

# Case Study 8a: Lifestyle Responses

- 55 y.o. T1, pump user
- No food or bolus 6am-3pm

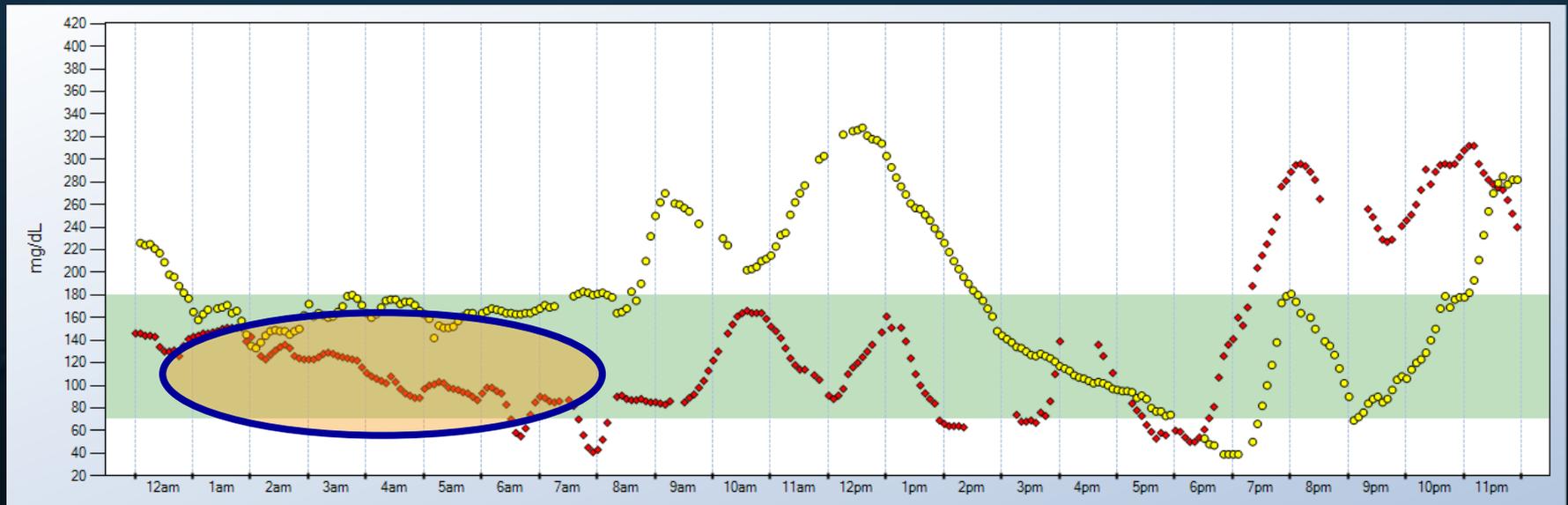
*Dentist appointment  
(root canal) at noon*



**STRESS CAN RAISE BLOOD GLUCOSE!!!**

# Case Study 8b: Lifestyle Responses

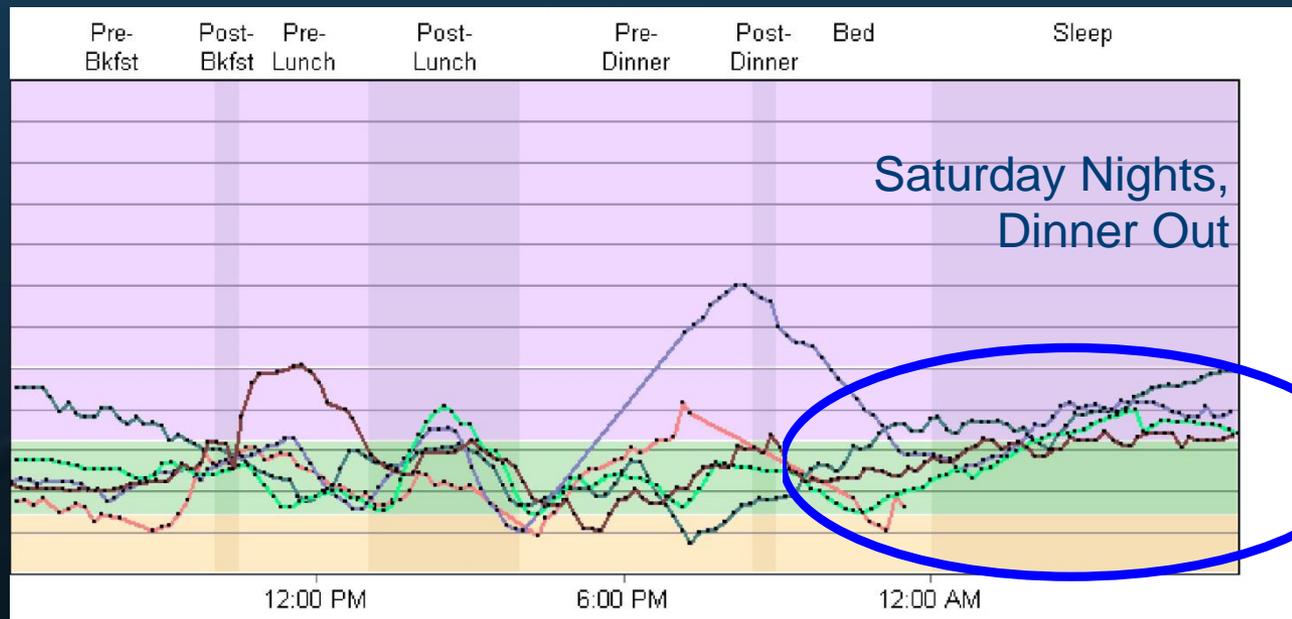
- Pump user
- Basal rates confirmed overnight
- **“yellow”** night: light cardio workout prior evening
- **“Red”** night: Lifting & cardio workout prior evening



**Experiencing delayed-onset hypoglycemia from heavy workouts. Consider temp basal reduction.**

# Case Study 8c: Lifestyle Responses

- Pump user
- Normal fasting readings during the week, but high on weekends



**Delayed rise from high-fat meals.  
Consider using temp basal increase.**

- ✓ Meal/Correction dose evaluation
- ✓ Bolus action curve
- ✓ Postprandial measurements
- ✓ Basal fine-tuning
- ✓ Patterns of hypoglycemia
- ✓ Lifestyle effects
- ✓ Medication effectiveness
- ✓ Day-of-the-week differences

**YOU DON'T  
HAVE TO  
DO ALL  
THIS AT  
ONE TIME!!!**

# Ingredients For Success

- Go in with the right expectations
- Use at least 90% of the time
- Look at the display 10-20 times per day
- Do not over-react to the data; take IOB into account
- Adjust your therapy based on trends/patterns
- Calibrate properly
- Minimize “nuisance” alarms

# Questions?

