

Interpreting Insulin Pump & CGM Data

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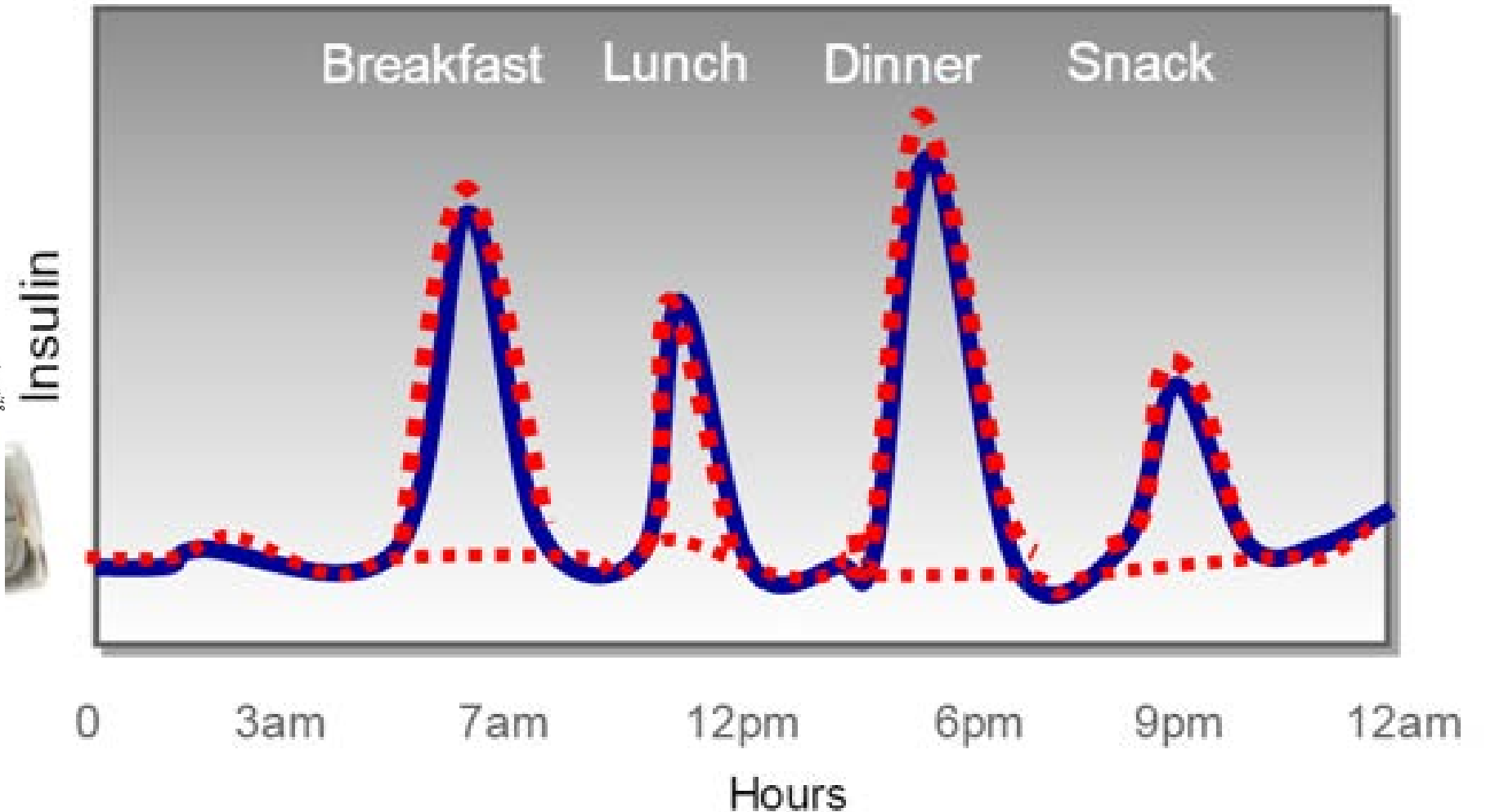
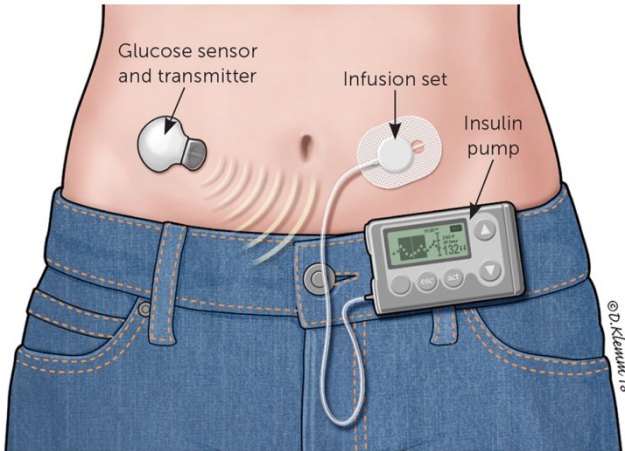


Learning Objectives

- Discuss definitions and features of CGM and insulin pump reports
- Utilize a systematic approach to review CGM data
- Analyze CGM and insulin reports to make medication changes



Quick Review: How a Pump Delivers Insulin



Available Pumps in U.S.



Omnipod (Insulet)



t:slim X2 with G6
CGM
(Tandem/Dexcom)



670G with Guardian 3
(Medtronic)



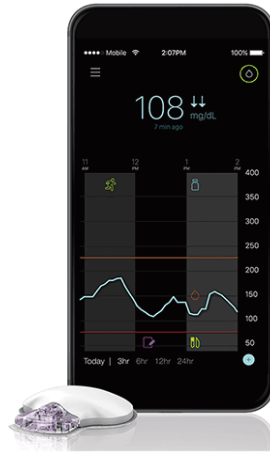
VGo



Continuous Glucose Monitoring



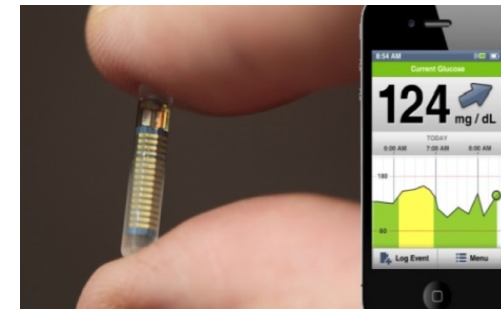
Dexcom G6



Medtronic Guardian Connect



Freestyle Libre Flash



Senseonics Eversense-Implantable

Insulin Pump Settings

Basal

Maximum Basal Rate	2.50 U/Hr
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Bolus Wizard	On
Units	g, mg/dL
Active Insulin Time (h:mm)	3:00
Maximum Bolus	25.0 U

Basal 1 (active)


24-Hour Total	28.100 U
---------------	----------

Time	U/Hr
00:00	1.00
02:30	1.10
08:00	1.15
13:00	1.30
22:00	1.05


Carbohydrate Ratio (g/U)

Time	Ratio	
0:00	15.0	

Insulin Sensitivity (mg/dL per U)

Time	Sensitivity	
0:00	40	

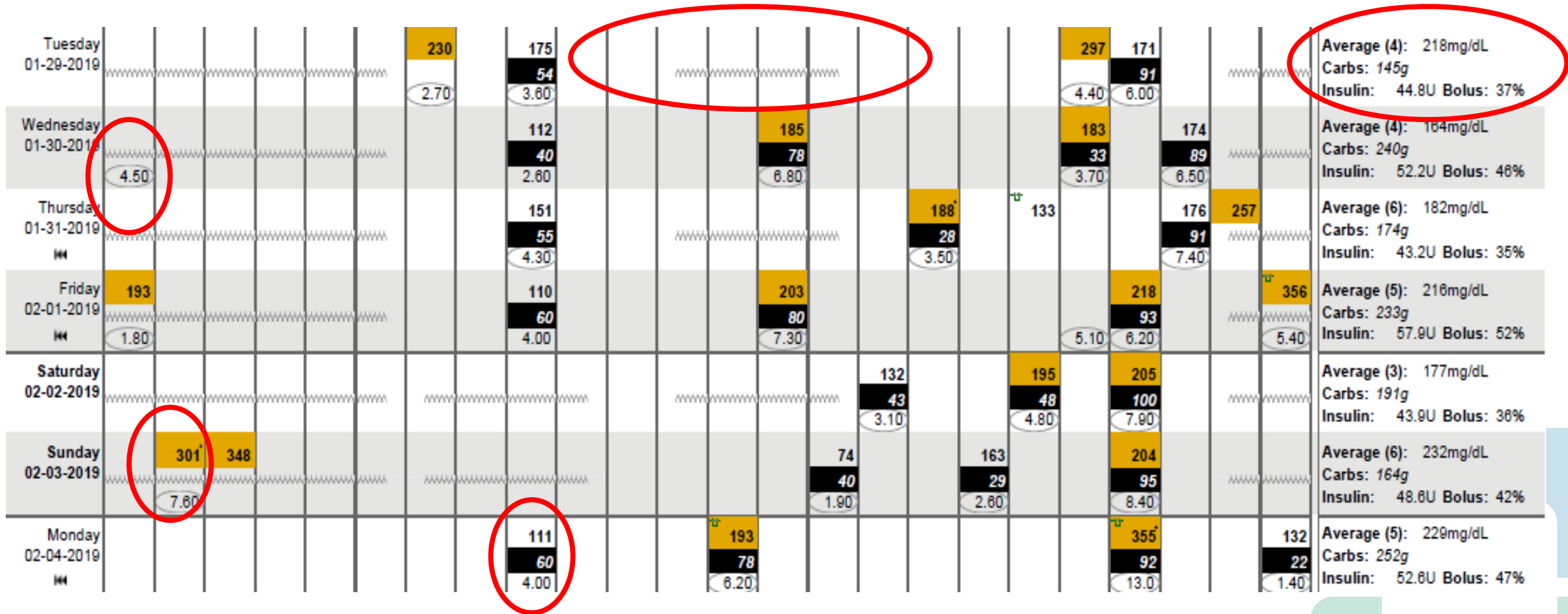
Blood Glucose Target (mg/dL)

Time	Low	High	
0:00	100	120	

Total daily dose (per day)	49 units
Bolus amount (per day)	21U (43%)
Auto Basal / Basal amount (per day)	28U (57%)

Meal (per day)	2.9
Carbs entered (per day)	190 ± 42 g

The Pump Report



Pump Automation

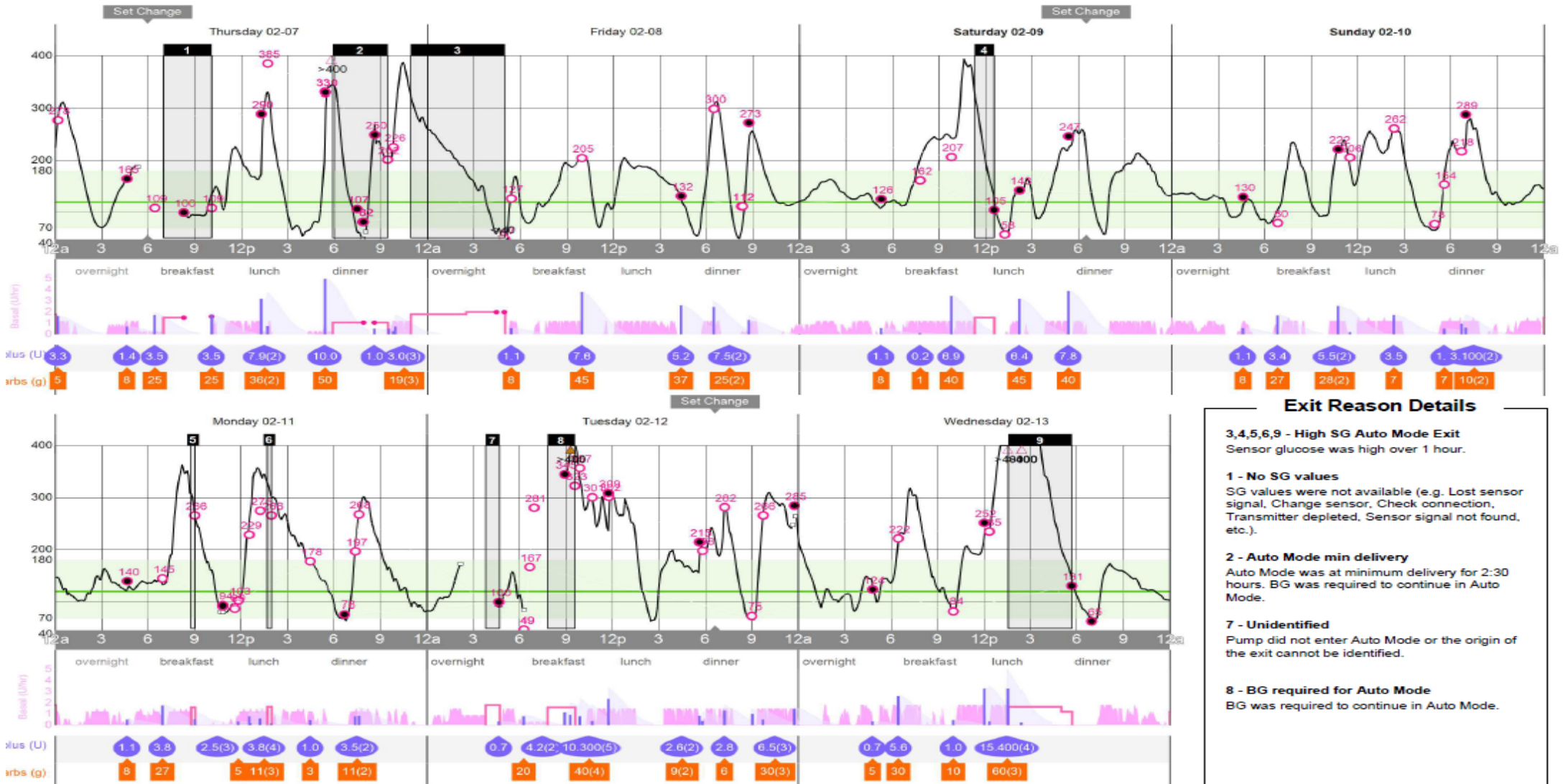
- Suspend insulin on low
- Predictive suspend
- Auto adjust basal insulin
- Auto correction doses



Predictive Suspend

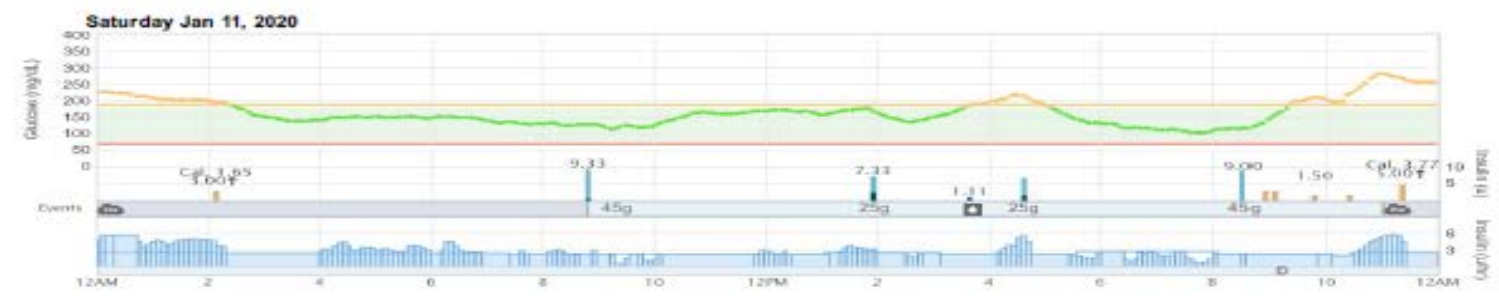
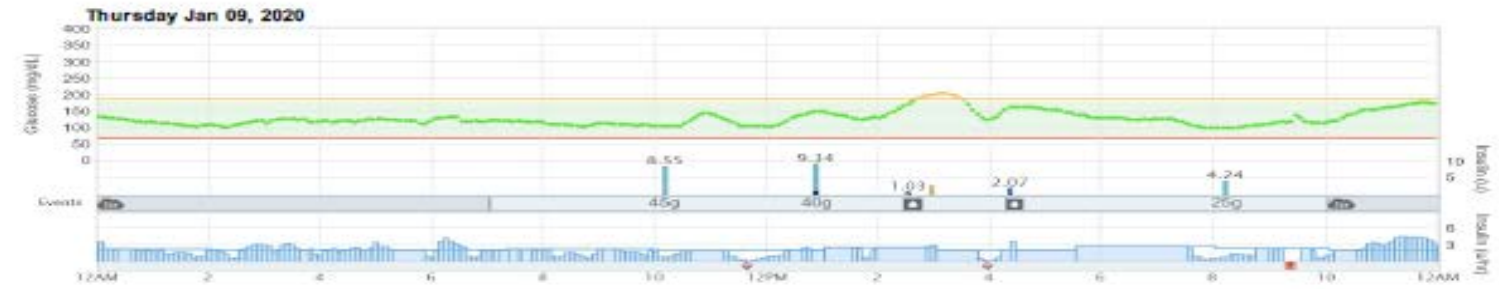


Medtronic 670G



Control IQ

Therapy Timeline | Wednesday Dec 18, 2019 - Tuesday Jan 14, 2020



Glucose: ● Above Target ● Target ● Below Target ● CGM
Bolus: ■ Correction ■ Food ■ Quick ■ Override ■ Extended ■ Control-IQ Auto
Basal: ▨ Control-IQ ▨ Profile ▨ Temp. ▨ Profile Setting
Events: □ Control-IQ Auto Bolus ✕ Exercise 🛌 Sleep 🍷 Carbs

Control-IQ: How It Works

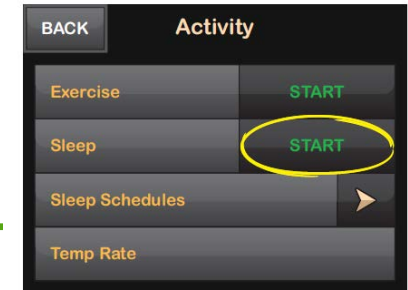
- Automatic basal attenuation (uses programmed rates)
 - Increases basals if predicted >160 mg/dL
 - Decreases basals if predicted <112.5 mg/dL
 - Suspends if predicted <70 mg/dL
- Automatic correction doses
 - Up to 1 every hour
 - Calculated at 60% of programmed correction factor (target of 110)
- User must still give boluses for CHO (and additional correction doses)
- Active insulin time 5 hours



Control-IQ: Sleep and Exercise

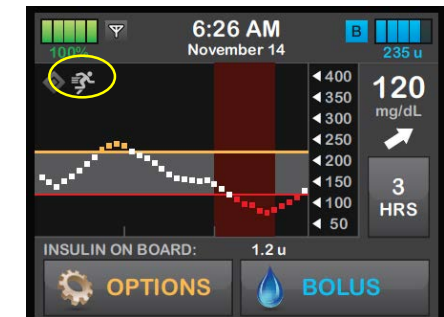
Sleep “Activity” schedule

- Target range to 112.5-120 mg/dL
- No automatic boluses



Exercise “Activity” schedule

- Temporary target range: 140-160 mg/dL
- Use like temp basal



Control-IQ vs Medtronic 670G rtCGM


	MiniMed 670G	Control-IQ
Calculate	<ul style="list-style-type: none"> Automatic basal delivery based on TDD 	<ul style="list-style-type: none"> Automated basal delivery based on basal rates Delivers auto-correction dose 1/h
Adjust	<ul style="list-style-type: none"> Can modify: <ul style="list-style-type: none"> - I:C ratios, insulin action time 	<ul style="list-style-type: none"> Can modify: <ul style="list-style-type: none"> - Basal rates, I:C ratios, sensitivities
Revert	Will revert to OL: <ul style="list-style-type: none"> Prolonged hyperglycemia, max/min insulin, no CGM data, sensor integrity 	Will revert to OL: <ul style="list-style-type: none"> if loss of CGM data
Educate	<ul style="list-style-type: none"> Follow system prompts to stay in Auto mode (entering BGs) Increase I:C ratios to make more aggressive 	<ul style="list-style-type: none"> Set sleep schedule Do not override boluses: extra insulin present from auto-corrections Read bolus prompts carefully
Sensor/Share	Guardian Sensor 3: <ul style="list-style-type: none"> 2-4 calibrations/d No remote monitoring 	Dexcom G6 sensor: <ul style="list-style-type: none"> Factory calibrated Phone view and remote monitoring

Temp Basals

- Temporarily increase or decrease basal settings
- A great option for high stress, sick days, steroid bursts, exercise
- Start the temp basal 1-2 hours prior to exercise or activity requiring the change
- Depending on pump report view, you may not see the temp basals
- Hybrid-closed loop
 - Temp target option (Medtronic), 150mg/dL
 - Exercise mode (Tandem), 140-160mg/dL



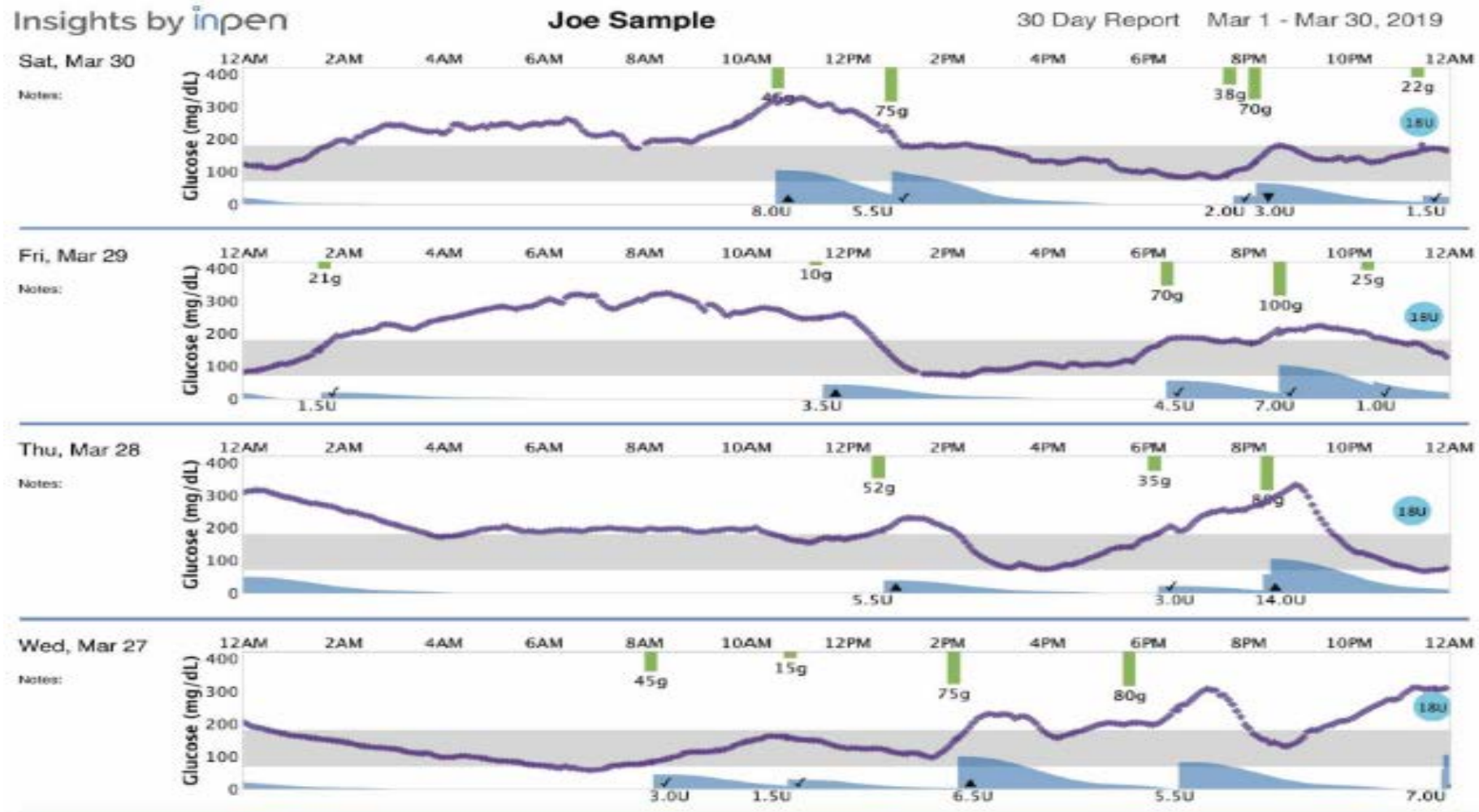
Bolus Pattern Management

- Does glucose go low after a correction dose?
 - May need a higher sensitivity
 - Ex. 1:60 instead of 1:50
 - Does glucose remain high after a correction dose?
 - May need a lower sensitivity
 - Ex. 1:50 instead of 1:60
 - Does the person spike high after eating?
 - Is the person bolusing BEFORE the meal
 - Counting carbs correctly?
 - May need a more intensive carb ratio
 - Ex. 1:8 instead of 1:10
 - Does the person go low after eating?
 - Counting carbs correctly?
 - May need a less intensive carb ratio
 - Ex. 1:10 instead of 1:8
- 

Data Management Systems

System	Website	What it Downloads
Glooko	www.glooko.com	Omnipod, Dexcom, Libre, Eversense, many glucose meters, Inpen
Dexcom Clarity	https://clarity.dexcom.com	Dexcom, Inpen
LibreView	www.libreview.com	Freestyle Libre
T:Connect	https://tconnecthcp.tandemdiabetes.com/hcp_account	Tandem insulin pumps with dexcom data
Carelink	https://carelink.medtronic.com/	Medtronic insulin pumps, Guardian Connect
Tidepool	https://tidepool.org/	All insulin pumps, Libre, Dexcom, Medtronic, many glucose meters, InPen
Eversense Data Management	https://us.eversensedms.com/	Eversense

Smart Pen Integration with CGM Data



Interpreting Reports



Clinical Targets for Continuous
Glucose Monitoring Data
Interpretation: Recommendations
From the International Consensus
on Time in Range

<https://doi.org/10.2337/dci19-0028>



Reviewing the Data: Key Metrics

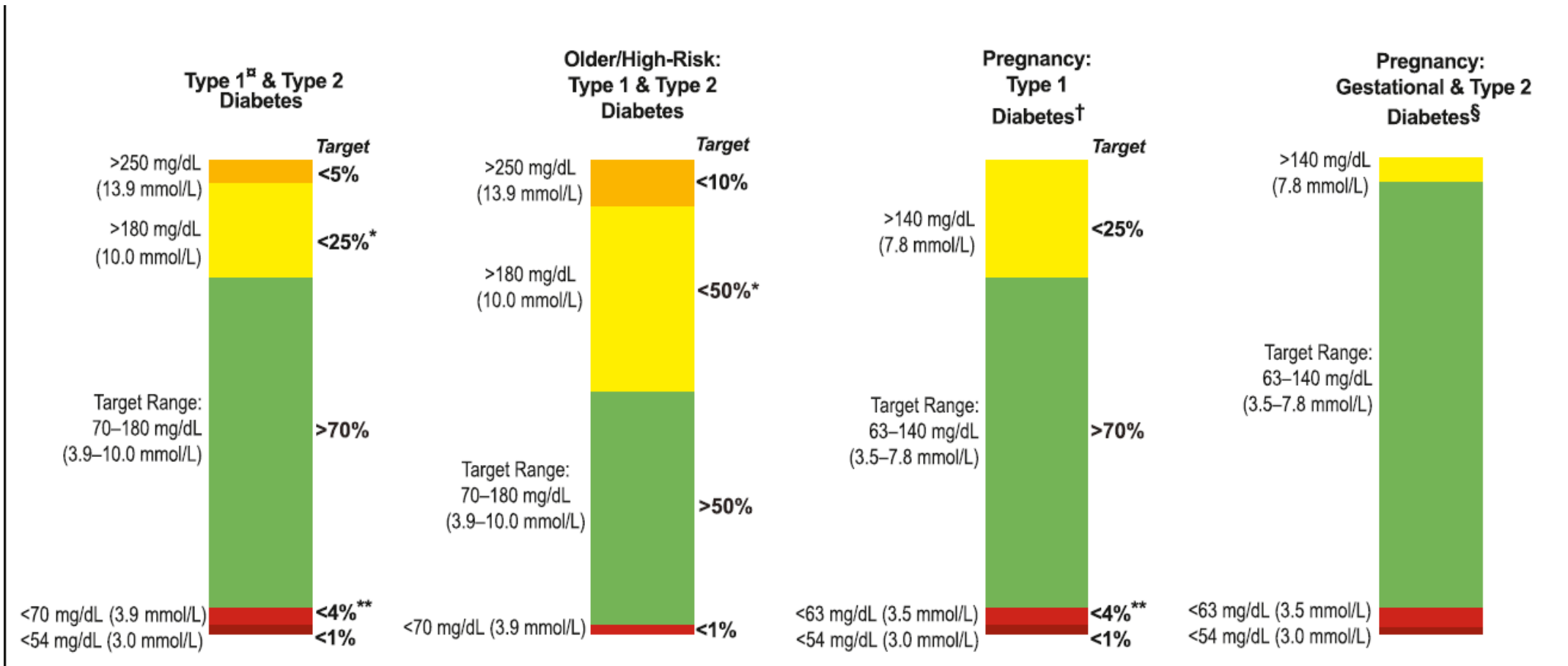
CGM Metric	Measure
Standardized visualization of data	Ambulatory glucose profile (AGP)
Mean glucose	Calculated
Hypoglycemia	<70mg/dL
Very low/clinically significant hypoglycemia	<54mg/dL
Hyperglycemia	>180mg/dL
Very high/clinical significant hyperglycemia	>250mgdL
Time in range	70-180mg/dL
Glycemic variability (coefficient of variation)	Standard deviation/mean, stable <36%
Glucose management indicator (GMI)	CGM version of estimated A1C
Recommend data sufficiency	70% sensor use over 14 days

Problem Solving

What Does All That Data
Mean?



Time in Range: International Consensus



Setting the Target Range

Overview

Patterns

Data

Compare

Statistics

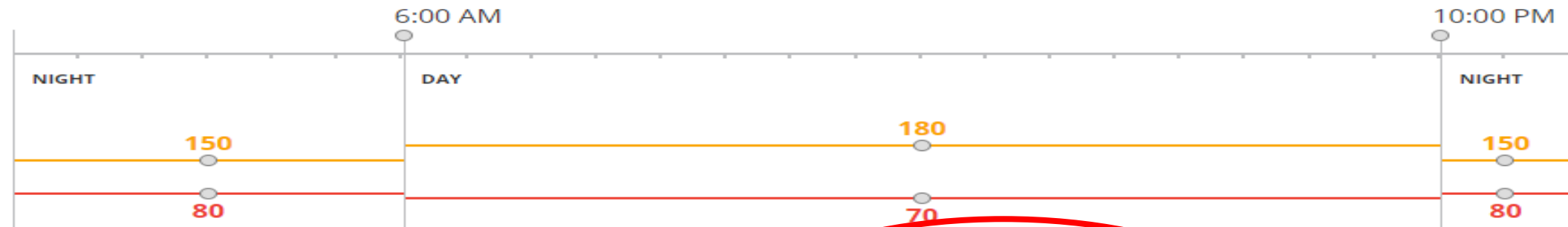
AGP

Settings

Settings

Glucose Time/Target Range (mg/dL)

Changes that you make here apply throughout Dexcom CLARITY, but they won't affect any settings on your CGM device.



Day

Start Time:

End Time:

Low Threshold: mg/dL

High Threshold: mg/dL

Night

Start Time:

End Time:

Low Threshold: mg/dL

High Threshold: mg/dL

Food

- ↑↑ 1. Carbohydrate quantity
- ↑ 2. Carbohydrate type
- ↑ 3. Fat
- ↑ 4. Protein
- ↑ 5. Caffeine
- ↓↑ 6. Alcohol
- ↓↑ 7. Meal timing
- ↑ 8. Dehydration
- ? 9. Personal microbiome

Medication

- ↓ 10. Medication dose
- ↓↑ 11. Medication timing
- ↓↑ 12. Medication interactions
- ↑↑ 13. Steroid administration
- ↑ 14. Niacin (Vitamin B3)

Activity

- ↓ 15. Light exercise
- ↓↑ 16. High-intensity and moderate exercise
- ↓ 17. Level of fitness/training
- ↓↑ 18. Time of day
- ↓↑ 19. Food and insulin timing

Biological

- ↑ 20. Insufficient sleep
- ↑ 21. Stress and illness
- ↓ 22. Recent hypoglycemia
- ↑ 23. During-sleep blood sugars
- ↑ 24. Dawn phenomenon
- ↑ 25. Infusion set issues
- ↑ 26. Scar tissue and lipodystrophy
- ↓↓ 27. Intramuscular insulin delivery
- ↑ 28. Allergies
- ↑ 29. A higher glucose level
- ↓↑ 30. Periods (menstruation)
- ↑↑ 31. Puberty
- ↓ 32. Celiac disease
- ↑ 33. Smoking

Environmental

- ↑ 34. Expired insulin
- ↑ 35. Inaccurate BG reading
- ↓↑ 36. Outside temperature
- ↑ 37. Sunburn
- ? 38. Altitude

Behavioral & Decision Making

- ↓ 39. Frequency of glucose checks
- ↓↑ 40. Default options and choices
- ↓↑ 41. Decision-making biases
- ↓↑ 42. Family relationships and social pressures

At least 42 factors affect glucose!

CGM: Guide to Data Interpretation

1) Gather Information

- Key metrics, AGP, % time in range, % hypoglycemia, % hyperglycemia, coefficient of variation
- DM medications, daily routine
- Data gaps, data sufficiency?

2) Safety

- Hypoglycemia-possible causes and solutions?

3) Focus on the positive

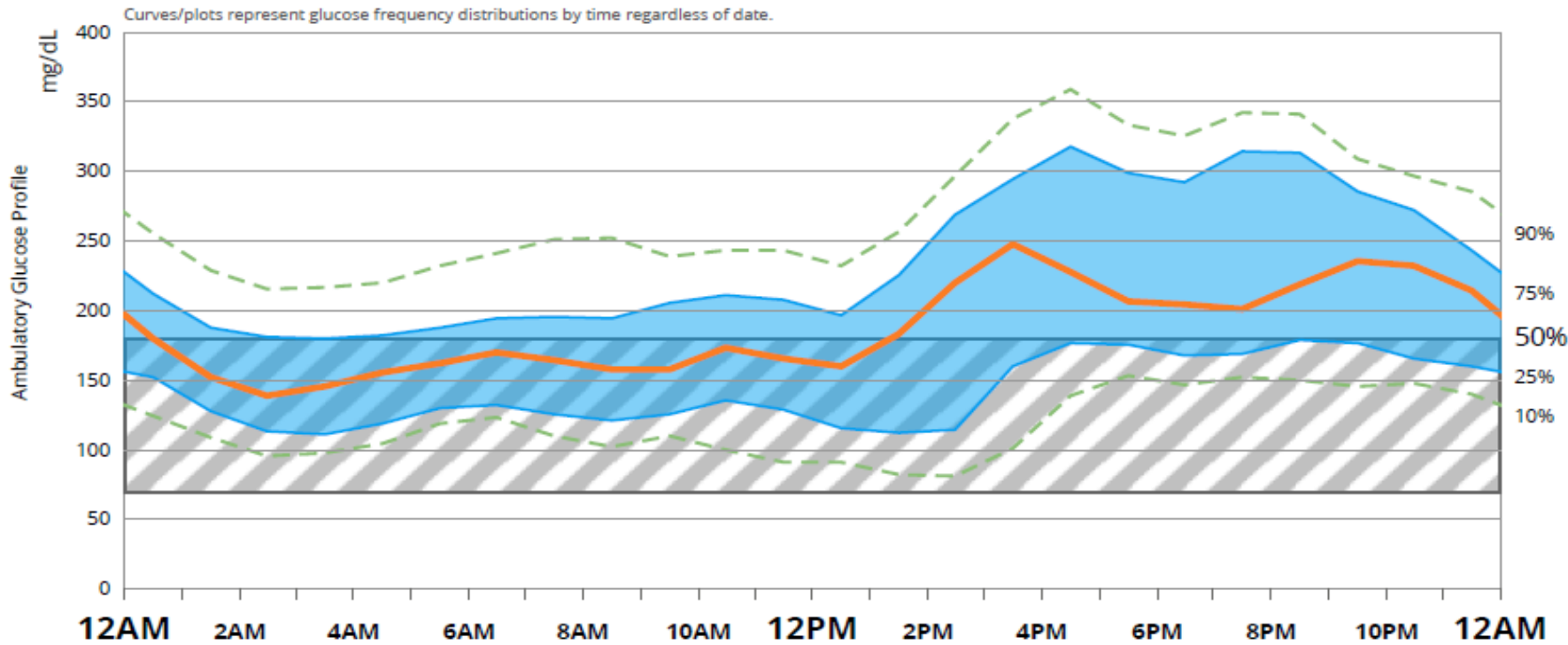
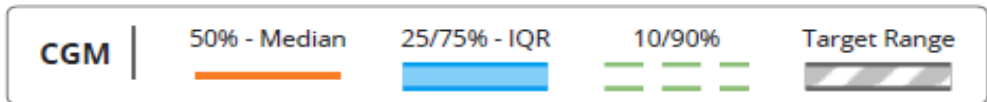
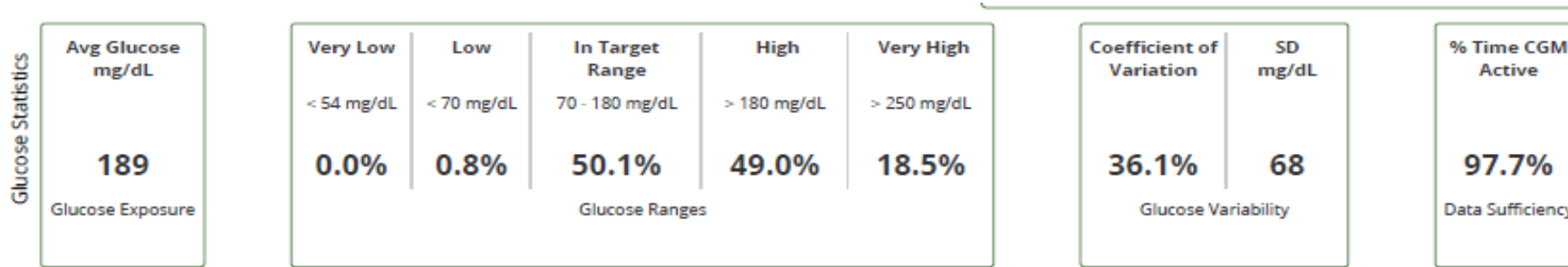
- Highest day time in range
- What worked well? (ex. Pre-bolusing, adequate sleep)

4) Focus on areas for improvement

- Hyperglycemia-possible causes and solution?



It's All About the AGP

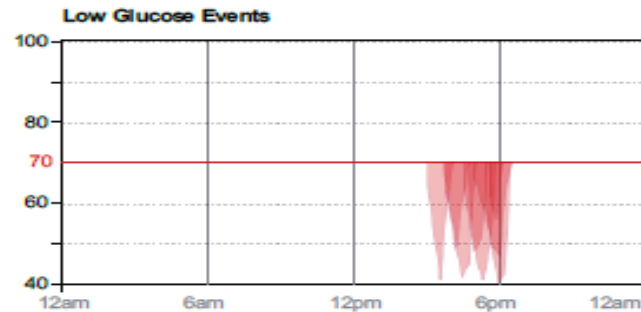
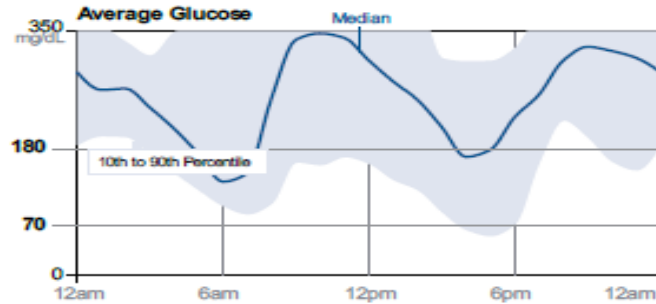


Snapshot: Hypoglycemia

Glucose

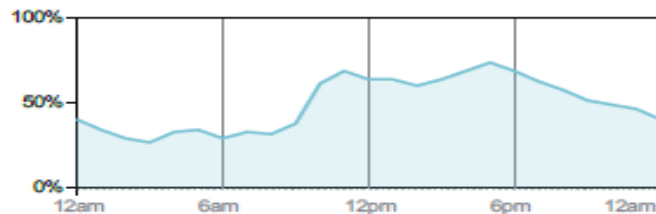
AVERAGE GLUCOSE	259 mg/dL
% above target	74 %
% in target	23 %
% below target	3 %

LOW GLUCOSE EVENTS	8
Average duration	64 Min



Sensor Usage

SENSOR DATA CAPTURED	50 %
Daily scans	2



DAILY CARBS _____ grams/day

INSULIN

RAPID-ACTING INSULIN _____ units/day

Meal _____

Correction _____

User Change _____

Manual _____

LONG-ACTING INSULIN _____ units/day

Total Daily Insulin _____ units/day

Comments

- Gaps found in the insulin data. 21 days in this reporting period have no recorded insulin events.
- Gaps found in food data. 21 days in this reporting period have no recorded food events.

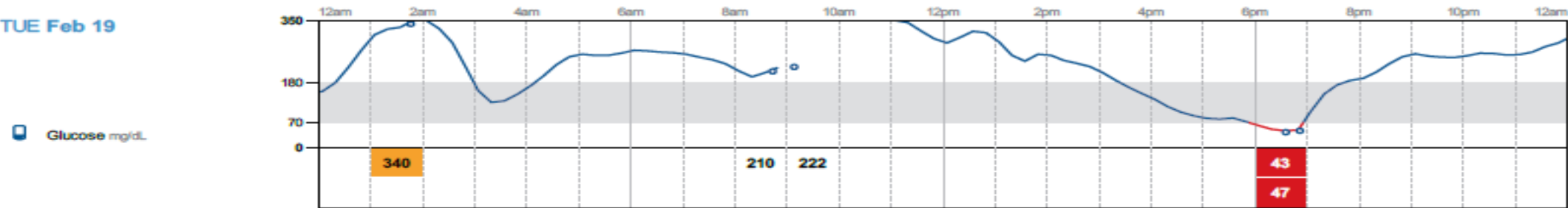
Caution with Data Gaps

Daily Log

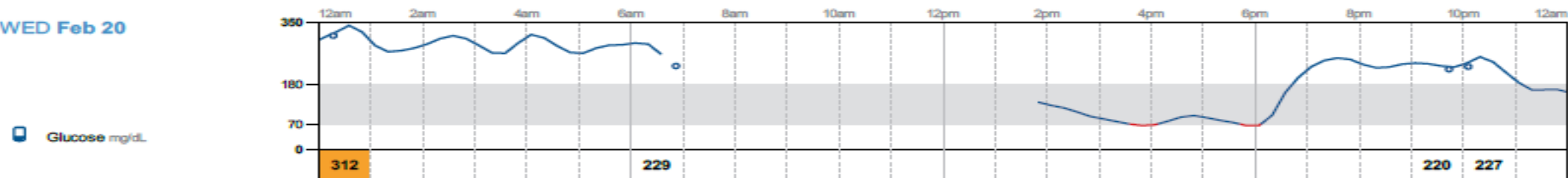
February 19, 2019 - May 19, 2019 (90 Days)

LibreView

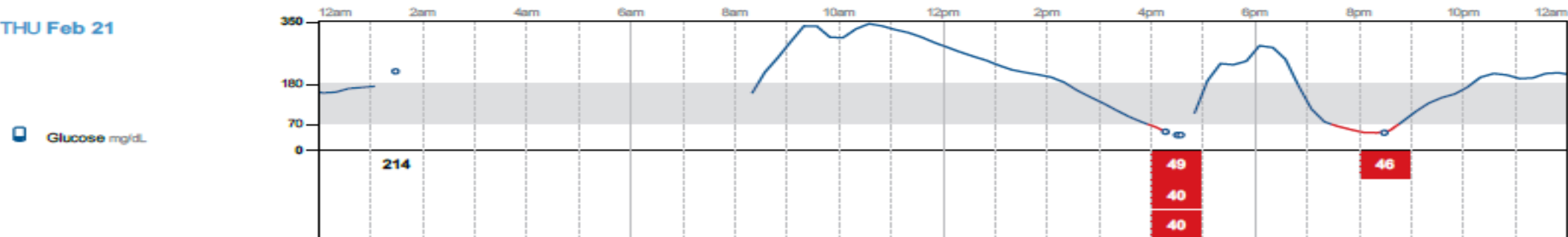
TUE Feb 19



WED Feb 20



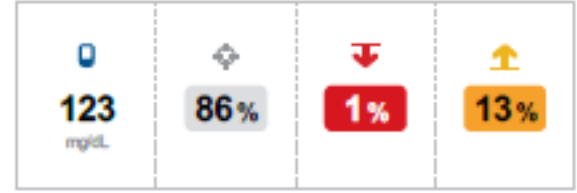
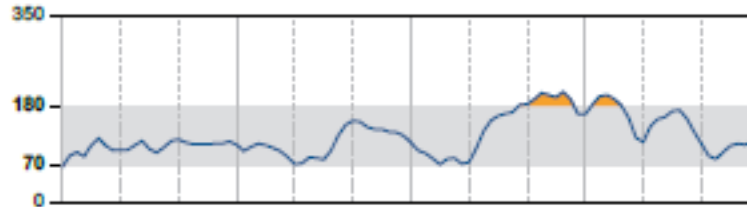
THU Feb 21



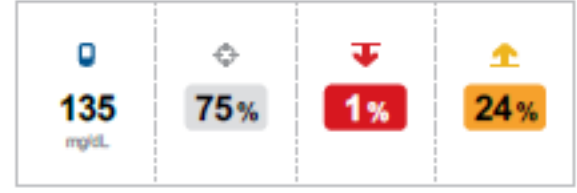
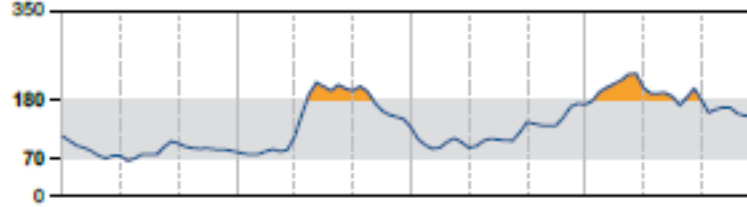
Comparing Different Days

Focus on the Positive-Best Day

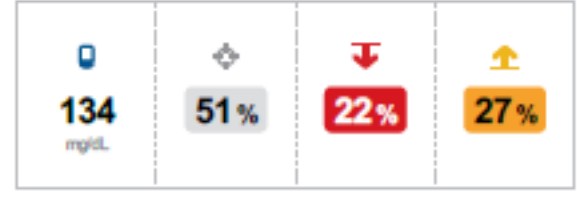
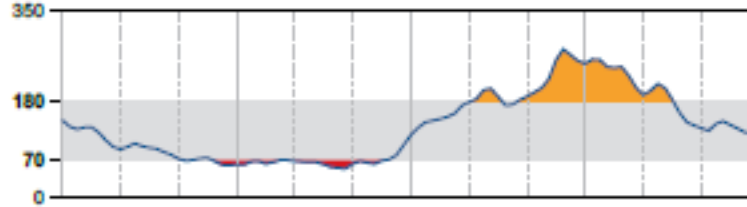
Fri Jun 23



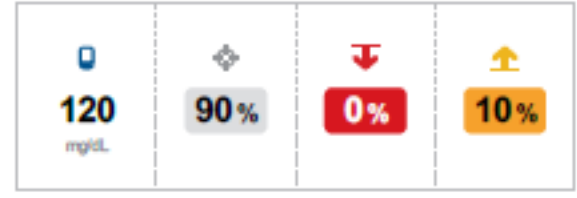
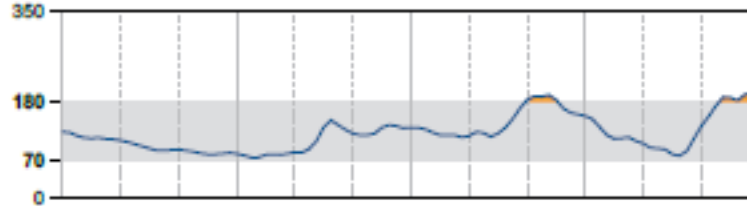
Sat Jun 24



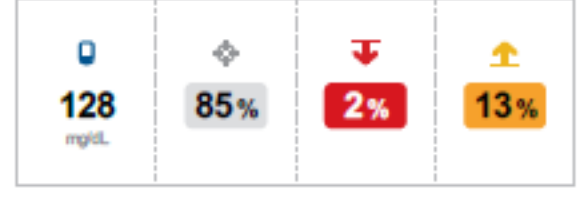
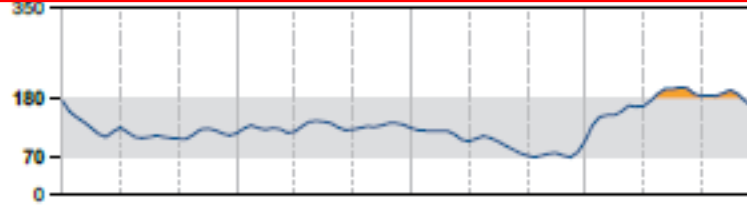
Sun Jun 25



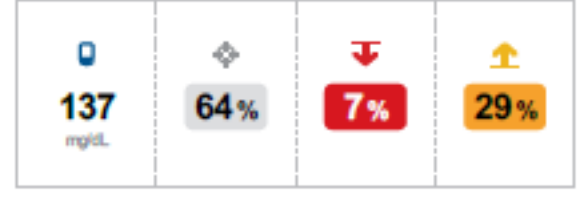
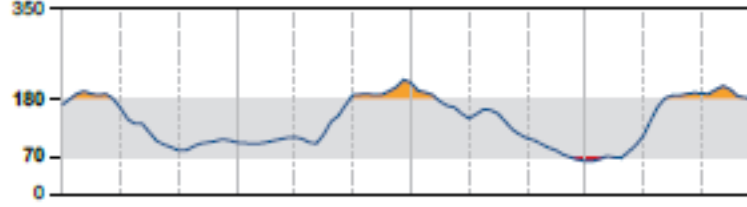
Mon Jun 26



Tue Jun 27



Wed Jun 28



Cases








Patient Case 1

- 55 year female with type 1 diabetes x 30 years
- Hypothyroid, Post-bariatric surgery, HTN
- BMI=29
- A1C=7.2%
- Wears Medtronic 670G



Pump Settings/Statistics


Statistics A

	Auto Mode (per week)	92% (6d 10h)
	Manual Mode (per week)	8% (14h)
	Sensor Wear (per week)	89% (6d 06h)
	Average SG \pm SD	156 \pm 58 mg/dL
	Average BG	171 \pm 82 mg/dL
	BG / Calibration (per day)	11.6 / 4.3
	Total daily dose (per day)	31 units
	Bolus amount (per day)	16U (52%)
	Auto Basal / Basal amount (per day)	15U (48%)
	Set Change	Every 3.3 days
	Reservoir Change	Every 3.3 days
	Meal (per day)	6.9
	Carbs entered (per day)	110 \pm 36 g
	Active Insulin time	3:00 hrs


Basal 1 (active)

24-Hour Total	19.800 U
Time	U/Hr
00:00	0.825


Carbohydrate Ratio (g/U)

Time	Ratio	
0:00	8.0	

Insulin Sensitivity (mg/dL per U)

Time	Sensitivity	
0:00	70	

Blood Glucose Target (mg/dL)

Time	Low	High	
0:00	100	120	

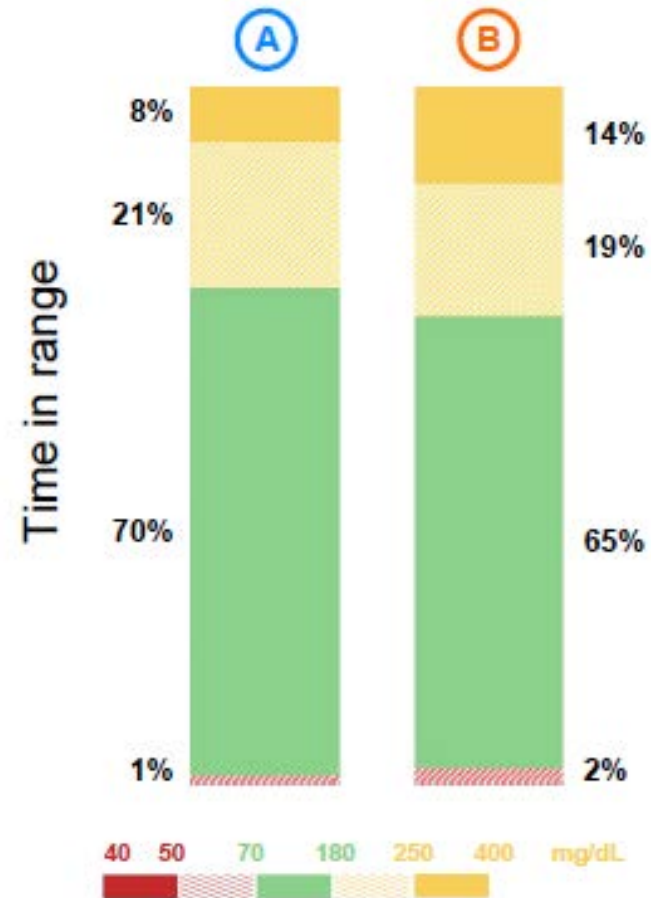


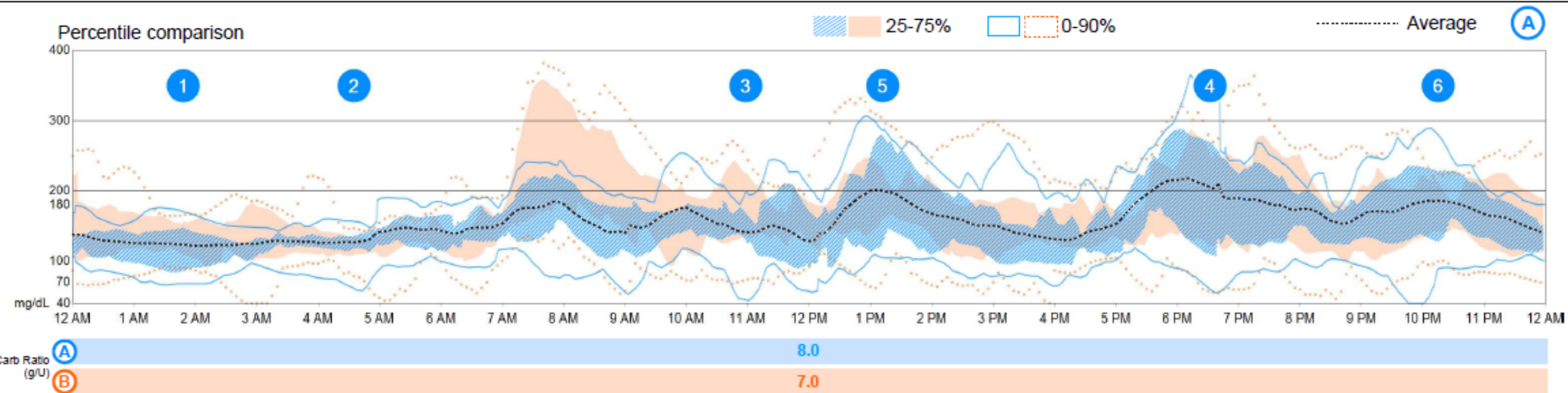
Auto Mode Exits

Auto Mode Exits

(A)

No Calibration	0
High SG Auto Mode Exit	• 1
Auto Mode max delivery	• 1
Auto Mode min delivery	0
BG required for Auto Mode	•• 2
Sensor Algorithm Underread	0
Sensor Updating	0
No SG values	• 1
Sensor Expired	0
Auto Mode disabled by user	0
Alarms	0
Pump Suspend by user	0
Auto Mode Warm Up	0
Unidentified	• 1





Hypoglycemic patterns (5)**

Hyperglycemic patterns (3)

1 1:20 AM- 2:15 AM
(1 occurrences)

2 4:23 AM- 4:48 AM
(1 occurrences)

3 10:45 AM- 11:10 AM
(1 occurrences)

4 5:20 PM- 7:45 PM

5 12:40 PM- 1:45 PM

6 9:50 PM- 10:40 PM

Additional Cases

Full reports available online
Please fill out the worksheet

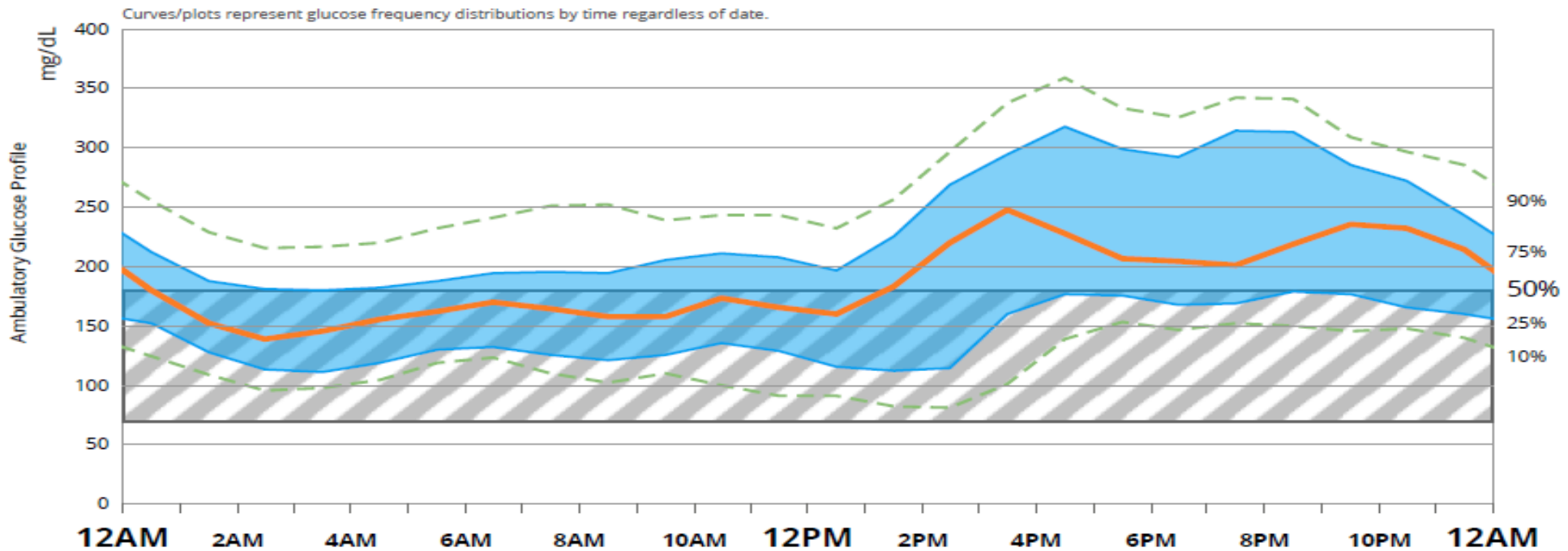
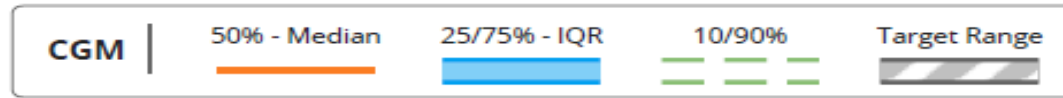
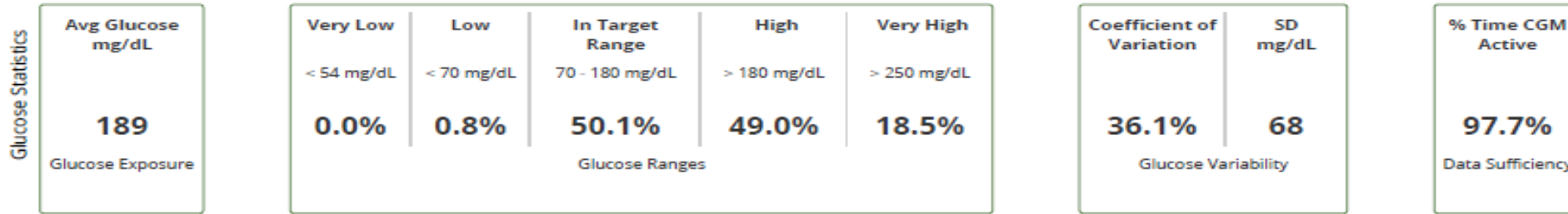


Jane is a 69yoF

- She has type 1 diabetes x 52 years
- Wears Dexcom G5
- A1C=8%, Wt=140lbs, BMI=23
- Current DM regimen:
 - Insulin glargine 14 units daily
 - Insulin aspart ICR: 1:20
 - Correction: 1:50 over 150



Jane's AGP



14 days

Thu Nov 21, 2019 - Wed Dec 4, 2019

7.8 %

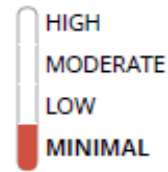
Glucose Management Indicator

189

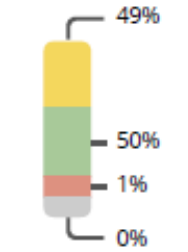
mg/dL
Average glucose (CGM)

68

mg/dL
Standard deviation (CGM)



Hypoglycemia risk



Time in range

Days with CGM data 100%
14 / 14

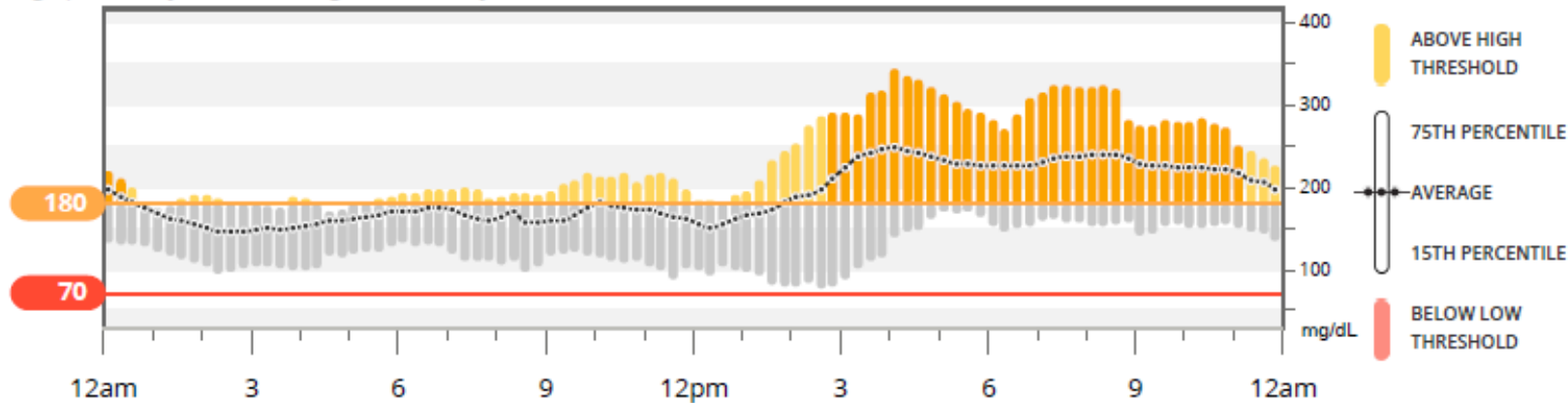
Avg. calibrations per day 4.0

Sensor usage

Top Patterns

- 1** Jane had a pattern of nighttime highs
Jane had a pattern of significant highs between 12:00 AM and 12:15 AM.
- 2** Jane had a pattern of daytime highs
Jane had a pattern of significant highs between 2:50 PM and 11:05 PM.
- 3** Jane's best glucose day was November 28, 2019
Jane's glucose data was in the target range about 96% of the day.

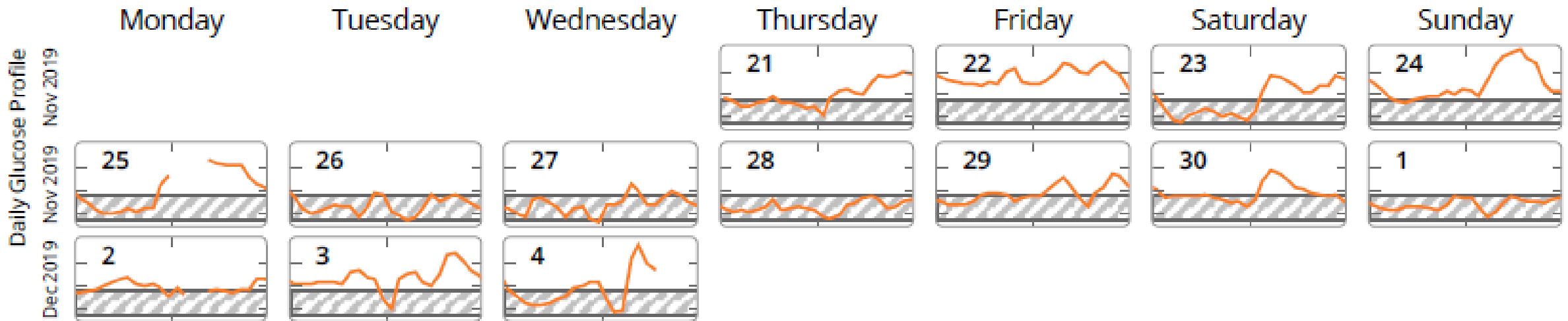
This graph shows your data averaged over 14 days



Day by Day

- What would you like to ask Jane?

The Y axis and target range are the same as on the Ambulatory Glucose Profile graph above.



What to do for Jane?

- Intensify carb ratio, when?
- Change basal insulin?
- Insulin pump or smart pen?
- Referral to diabetes education?
- Referral to dietitian?



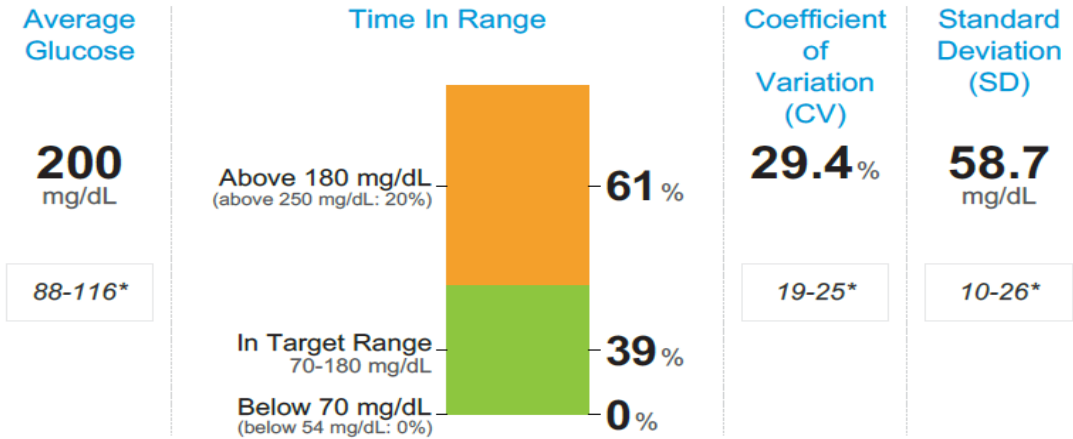
Matt is a 44yoM

- He has type 2 diabetes x 3 years
- Other comorbidities: HTN, hyperlipidemia
- A1C=8.4%, BMI=37kg/m²,
- Wears Freestyle Libre
- Current DM regimen:
 - Insulin glargine 30 units qpm
 - Metformin 1000mg BID
 - Glimepiride 2g BID



Matt's AGP

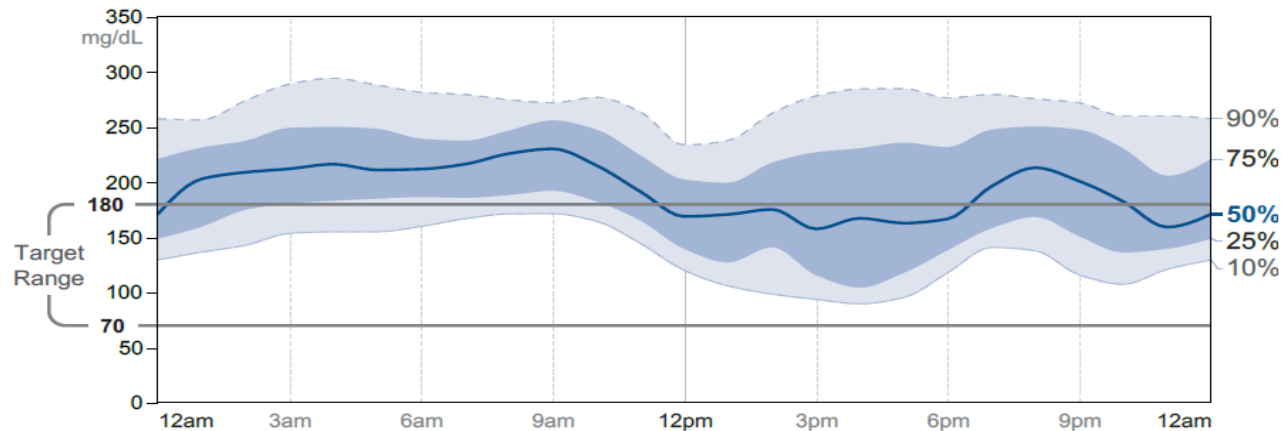
Summary



*Reference ranges calculated from population without diabetes.

Ambulatory Glucose Profile

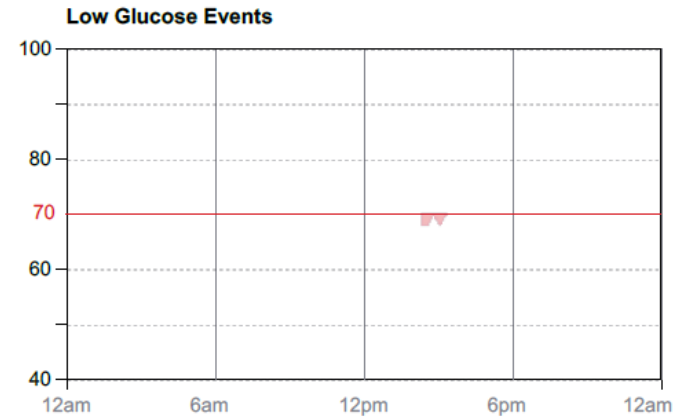
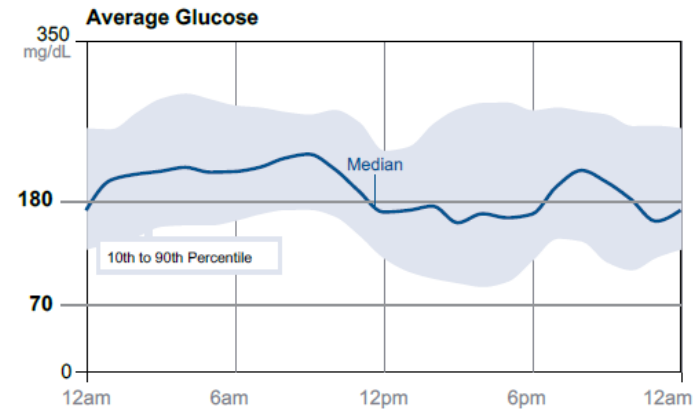
Curves/plots represent glucose frequency distributions by time regardless of date



Glucose

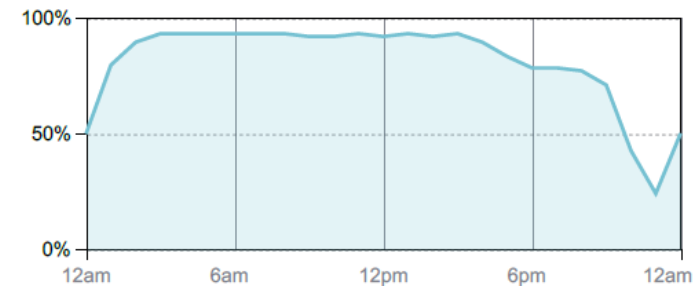
AVERAGE GLUCOSE	200 mg/dL
% above target	61 %
% in target	39 %
% below target	0 %

LOW GLUCOSE EVENTS	1
Average duration	60 Min



Sensor Usage

SENSOR DATA CAPTURED	82 %
Daily scans	9

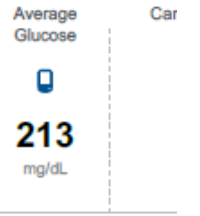
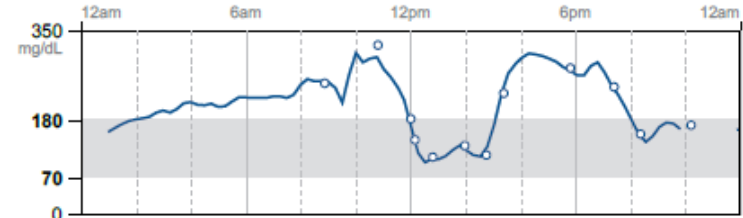


Day by Day

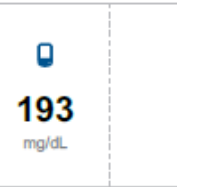
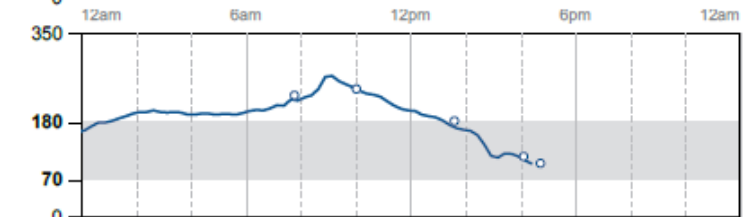
- What would you like to ask Matt?

Glucose

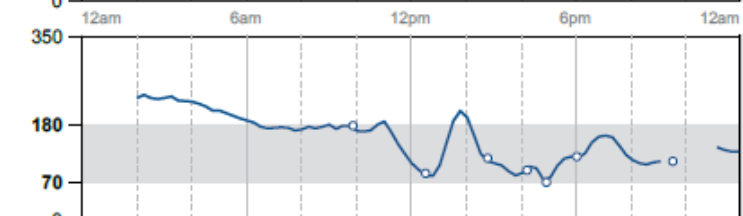
Sat
Jan 18



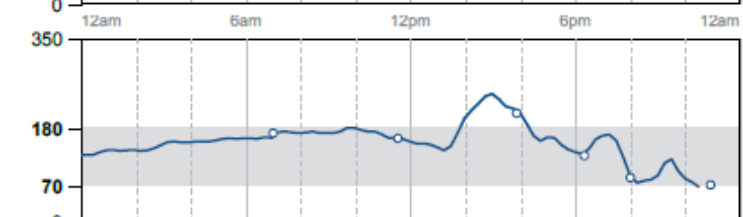
Sun
Jan 19



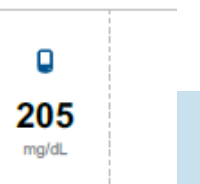
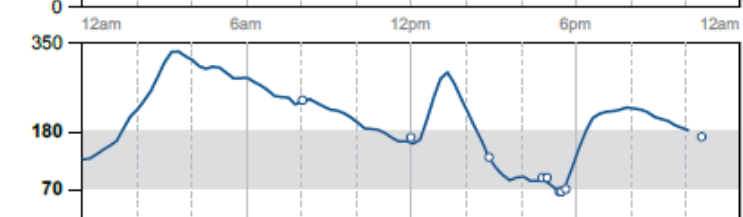
Mon
Jan 20



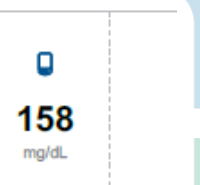
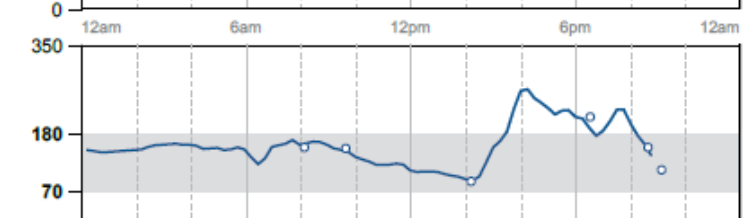
Tue
Jan 21



Wed
Jan 22



Thu
Jan 23



What to do for Matt?

- Increase basal?
- Change metformin or glimepiride?
- Referral to diabetes education?
- Referral to dietitian?
- Add on new agents?



3 Pump Cases

- All people with type 1 DM, wearing insulin pumps and CGM
- T:Connect
- Glooko
- Carelink





Cleveland Clinic

Every life deserves world class care.

Extra Slides



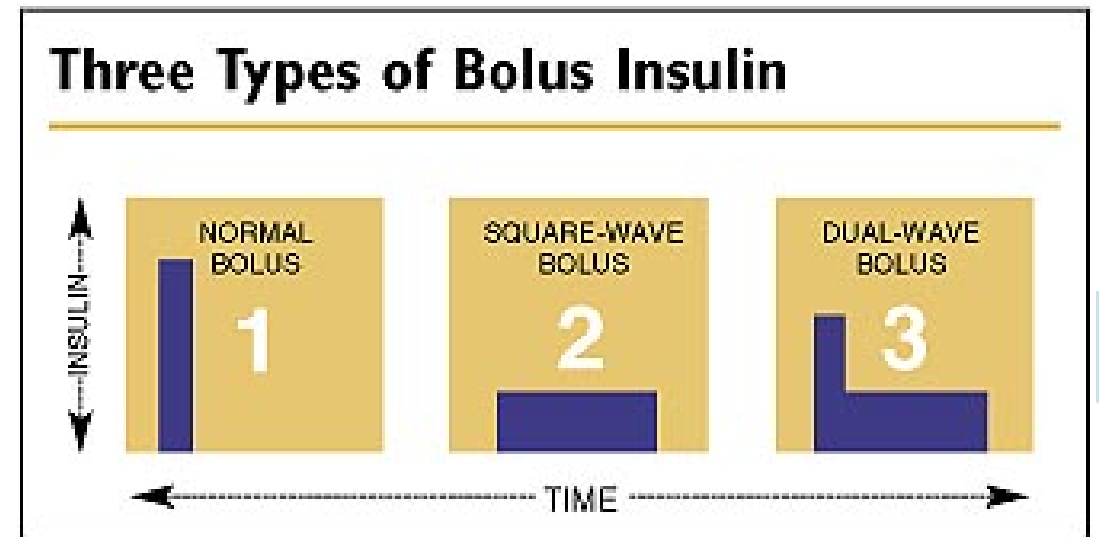
Insulin Pump Terminology

- Basal rate - a continuous delivery of insulin, “background” insulin
- Bolus – used for carbohydrate and correction doses
- Insulin-to-carb ratio – how many grams of carbohydrates will be covered by 1 unit of insulin
- Insulin sensitivity factor (aka correction bolus or ISF) – how much 1 unit of insulin is expected to lower glucose
- Target – the goal glucose level used for corrections or reverse correction
- Insulin-on-board (aka active insulin time or IOB) – a pump feature that keeps track of a previous bolus

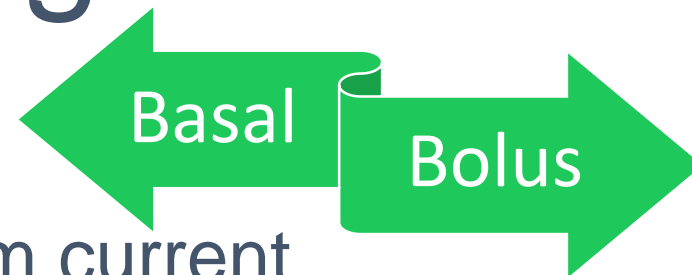


Common Pump Features

- Bolus calculator
- Temporary basal or temp target
- Insulin-on-board/active insulin feature
- Multiple basal patterns
- Small dose increments
- Integration with CGM
- Extended boluses



Insulin Pump Settings





- Use calculations as a starting point
 - Weight based insulin dosing or convert from current basal/bolus regimen with a 25% reduction
 - Rule of 1800 for sensitivity
 - Rule of 500 for carb ratio
 - Basal/bolus balance 50/50 (will vary based on carb intake)
- Fix fasting first
 - Begin with basal rate testing
- Once basals at goal, focus on bolus settings



Calculations

- Rule of 1800
 - Divide by 49 (TDD)
 - =36.73
- Rule of 500
 - Divide by 49
 - =10.2

Total daily dose (per day)	49 units
Bolus amount (per day)	21U (43%)
Auto Basal / Basal amount (per day)	28U (57%)

Carbohydrate Ratio (g/U)			Insulin Sensitivity (mg/dL per U)		
Time	Ratio		Time	Sensitivity	
0:00	15.0		0:00	40	

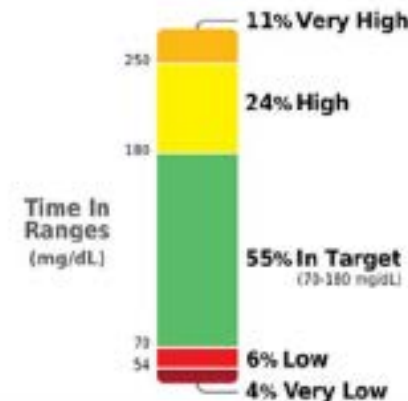


Ambulatory Glucose Profile

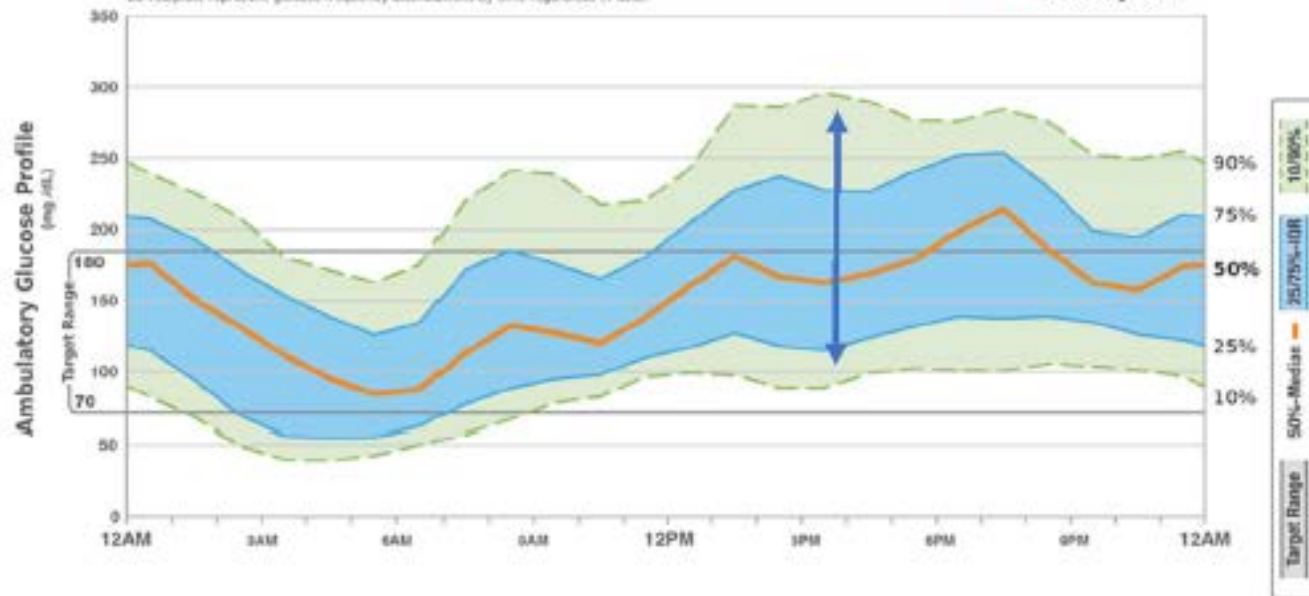
capturAGP® Name _____

Glucose Statistics

15 Feb 2018 - 01 Mar 2018	14.5 days
% Time CGM is Active	70.6%
Average Glucose	156 mg/dL
Glucose Management Indicator (GMI)	7.0%
Coefficient of Variation (CV)	46%
Standard Deviation (SD)	72 mg/dL



Curves/plots represent glucose frequency distributions by time regardless of date.



The Y axis scale and target range are the same as on the Ambulatory Glucose Profile graph above.



Figure 3. Ambulatory Glucose Profile

Time in Range Targets

Table 3—Guidance on targets for assessment of glycemic control for adults with type 1 or type 2 diabetes and older/high-risk individuals

Diabetes group	TIR		TBR		TAR	
	% of readings; time per day	Target range	% of readings; time per day	Below target level	% of readings; time per day	Above target level
Type 1*/type 2	>70%; >16h, 48 min	70–180 mg/dL (3.9–10.0 mmol/L)	<4%; <1 h <1%; <15 min	<70 mg/dL (<3.9 mmol/L) <54 mg/dL (<3.0 mmol/L)	<25%; <6 h <5%; <1 h, 12 min	>180 mg/dL (>10.0 mmol/L) >250 mg/dL (>13.9 mmol/L)
Older/high-risk# type 1/type 2	>50%; >12 h	70–180 mg/dL (3.9– 10 mmol/L)	<1%; <15 min	<70 mg/dL (<3.9 mmol/L)	<10%; <2 h, 24 min	>250 mg/dL (>13.9 mmol/L)

Each incremental 5% increase in TIR is associated with clinically significant benefits for individuals with type 1 or type 2 diabetes (26,27). *For age <25 years, if the A1C goal is 7.5%, set TIR target to approximately 60%. See the section **CLINICAL APPLICATION OF TIME IN RANGES** for additional information regarding target goal setting in pediatric management. #See the section **OLDER AND/OR HIGH-RISK INDIVIDUALS WITH DIABETES** for additional information regarding target goal setting.