An Introduction to Continuous Glucose Monitoring

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I have financial interest, arrangement or affiliation with:

Organisation	Relationship
University of Glasgow	Employee
Woodleys	Sponsor of this talk
BSAVA	Co-chair of Council (RUMA CA&E)
	Petsavers Grant
Others	Paid articles, lecturing, consultancy for Dechra Boehringer, IDEXX, Royal Canin and various veterinary associations, Kit Sturgess (couple of slides)

Plan

- **Introduction**
- How do they work
- When should they be used (and when not!)
- How to interpret the data
- Case Examples

European Society of Veterinary Endocrinology ALIVE consensus

- Clinical signs are paramount
  - Normalisation of body condition score, no PU/PD, no ketones, no hypos etc.
  - Scoring schemes useful.
- Good control is related to glycaemic control (however assessed)
  - No good evidence that setting a specific glycaemic goal is correlated with a specific treatment outcome
- Current methods of assessing glycaemic control have problems
  - Blood glucose curves / CGMS – substantial day to day variation
  - Fructosamine assays are unreliable
  - Urine glucose – negatives may indicate hypoglycaemia
- ALIVE diabetic score system

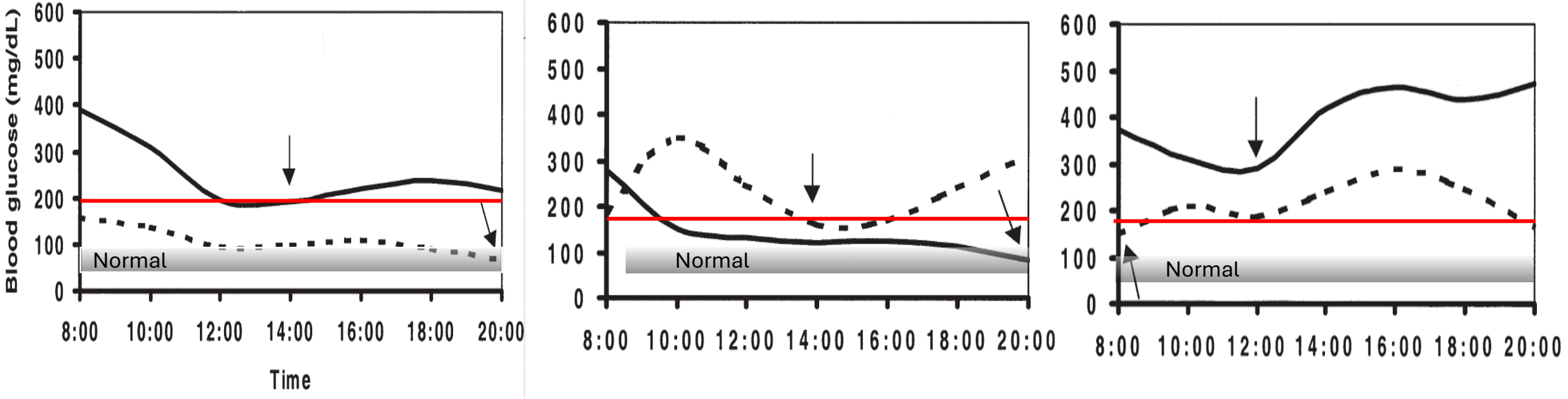
ALIVE DCS

Total = 0-12

Aim to keep as low as possible without hypoglcyaemia

FACTOR	SCORE
Unintended Weight Loss 0 = None, or gained since last examined 1 = Mild (<5% loss) 2 = Moderate (5-10% loss) 3 = Severe (>10% loss)	...
Polyuria and polydipsia 0 = Normal 1 = Mild (some increase noted by owner) 2 = Moderate (increased filling of water bowl) 3 = Severe (constantly at bowl)	...
Appetite 0 = Normal or decreased appetite (if decreased appetite exclude DKA or concurrent disease) 1 = Mild polyphagia (finishes eagerly) 2 = Moderate polyphagia (finishes eagerly and begs for more) 3 = Severe polyphagia (obsessed with food)	...
Attitude/activity 0 = Normal 1 = Mild decrease (a bit less running and jumping) 2 = Moderate decrease (a lot less running and jumping) 3 = Severe decrease (lying about all the time) (*consider DKA in the ill patient with diabetes mellitus)	...
TOTAL SCORE	...

Interpreting glucose curves in healthy diabetic dogs

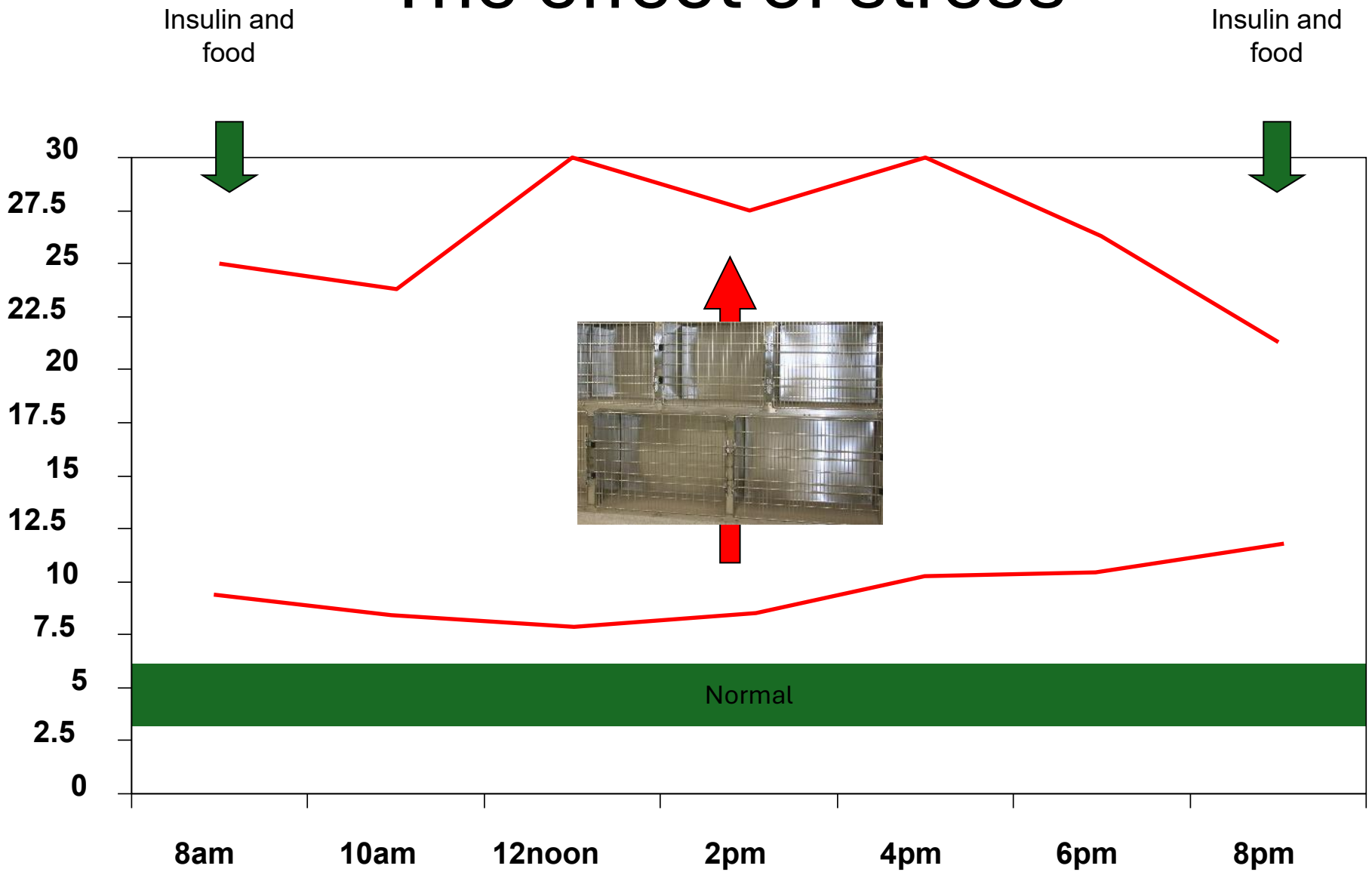


Same dog – 3 visits, 2 curves each time, one week apart

No change in insulin dose, timing, exercise or food

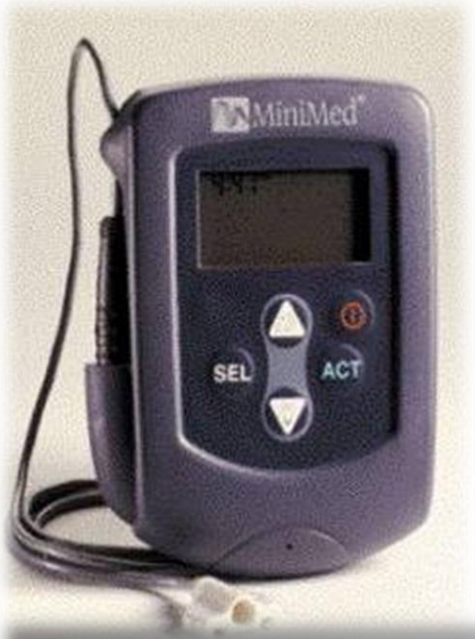
Fleeman and Rand (2003) *J Am Vet Med Assoc* **222** : 317–321

The effect of stress



CGMS in small animals

- Minimed
  - Davison and others (dogs)
  - Ristic and others (cats)
- Guardian REAL-time
  - Moretti and others (cats)
    - wireless
  - i-Pro similar
    - No real time display
- Glucoday
    - Wired
- Dexcom G4
    - Wireless
    - Transmitter life
      - = expensive
- Implantable systems – Eversense XL



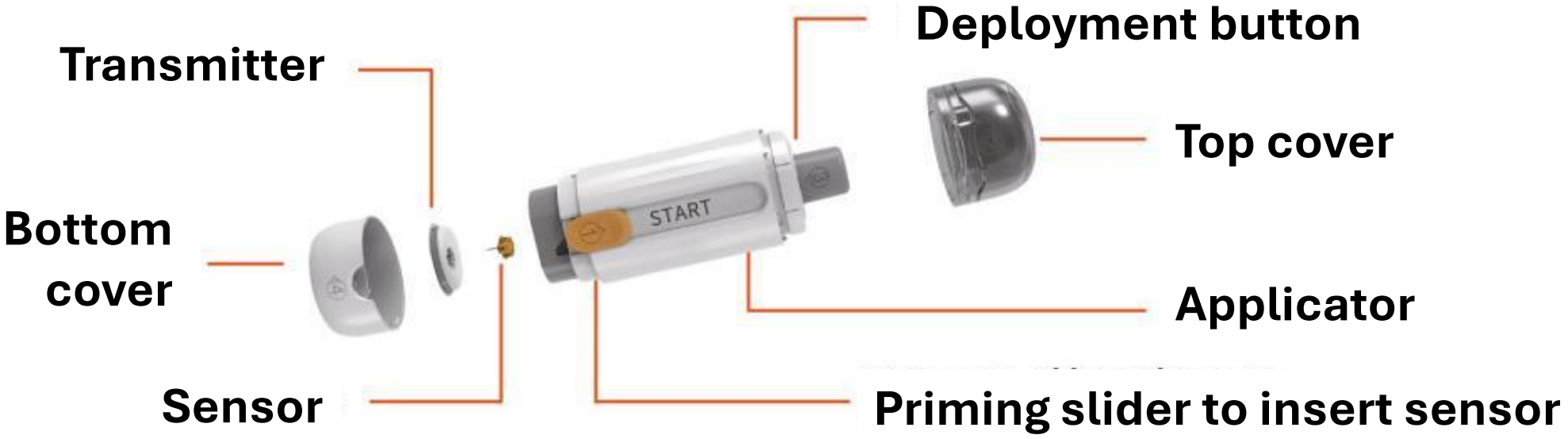
Flash CGMS

FreeStyle Libre

Corradini S, Pilosio B, Dondi F, Linari G, Testa S, Brugnoli F, Gianella P, Pietra M, Fracassi F (2016) Accuracy of a Flash Glucose Monitoring System in Diabetic Dogs. *Journal of Veterinary Internal Medicine* **30**: 983-8

InSight® Vet CGM

Continuous Glucose Monitoring System



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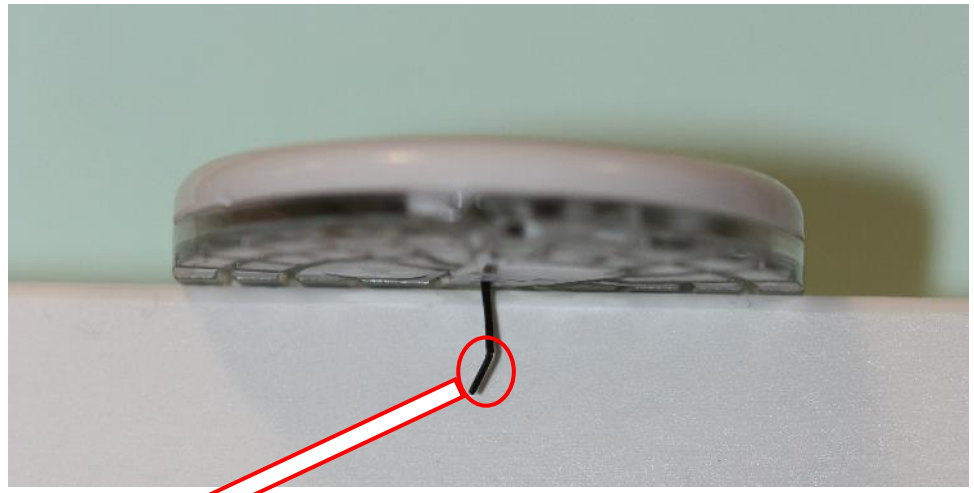
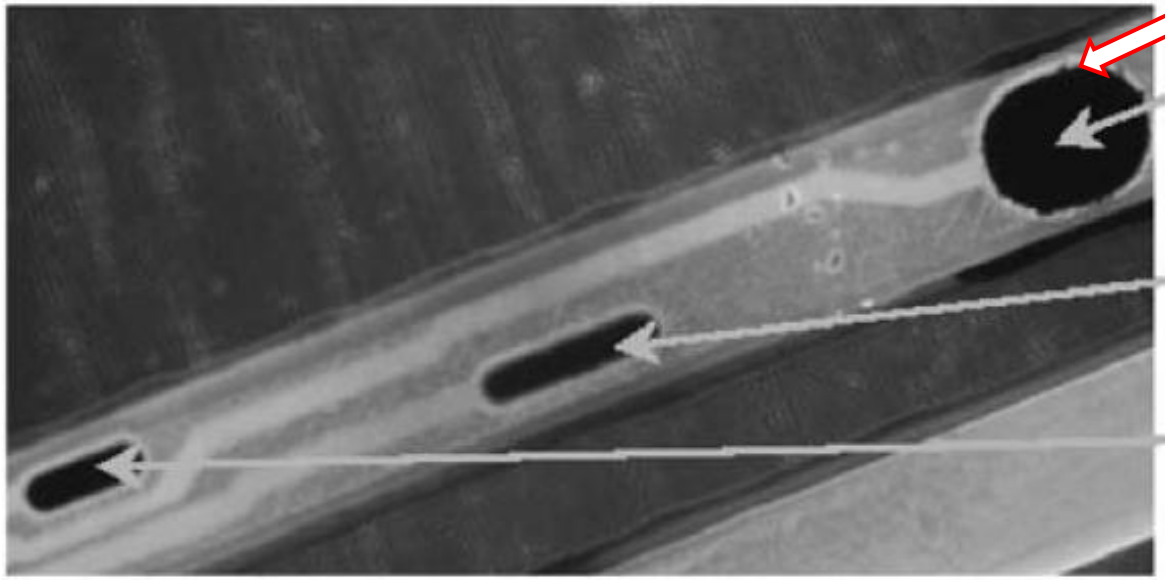
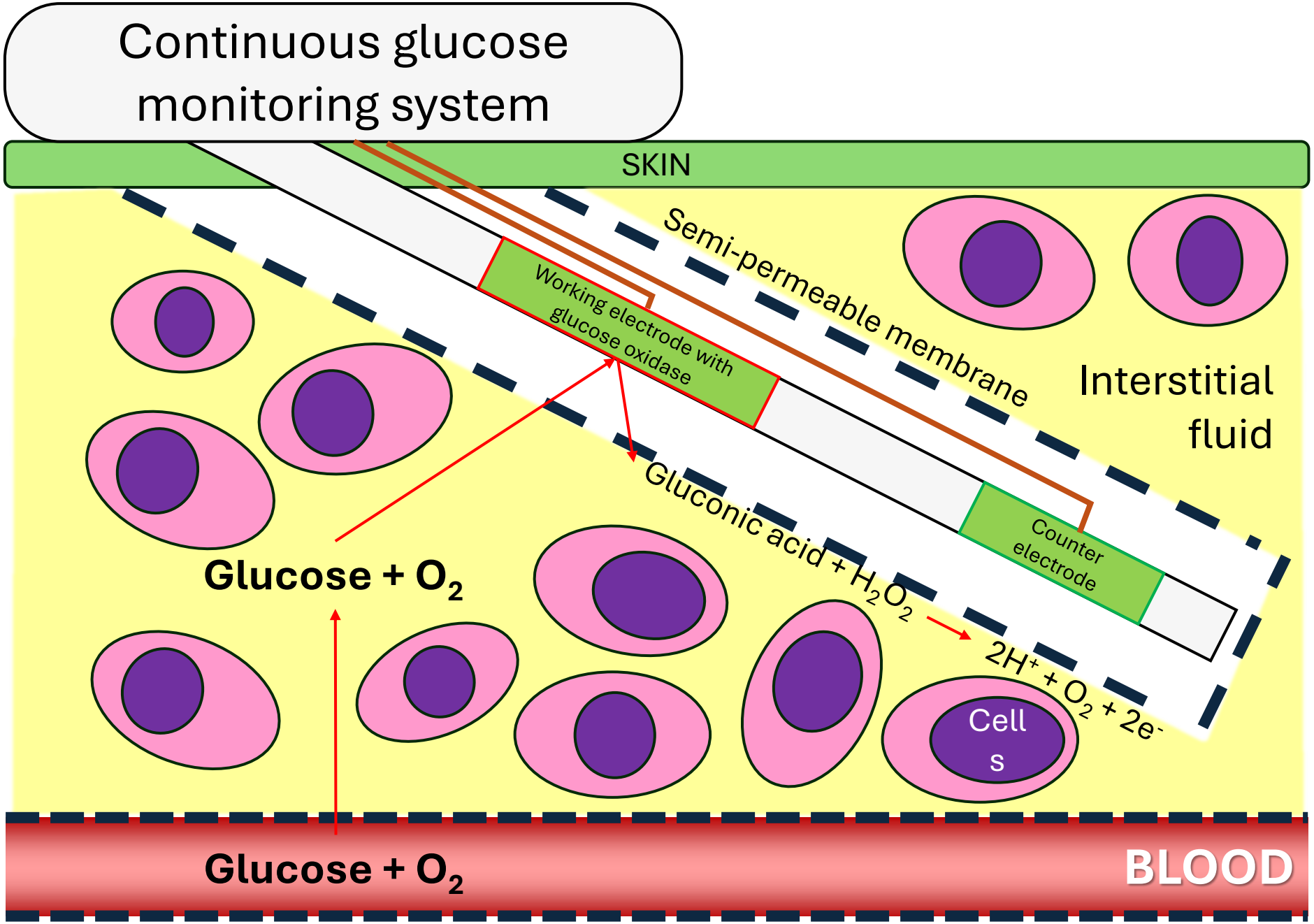
CGMS: how they work





Mang and others (2005) Diabetes Technology and Therapeutics **7** : 163-173

How CGMS work



CGMS do not measure blood glucose

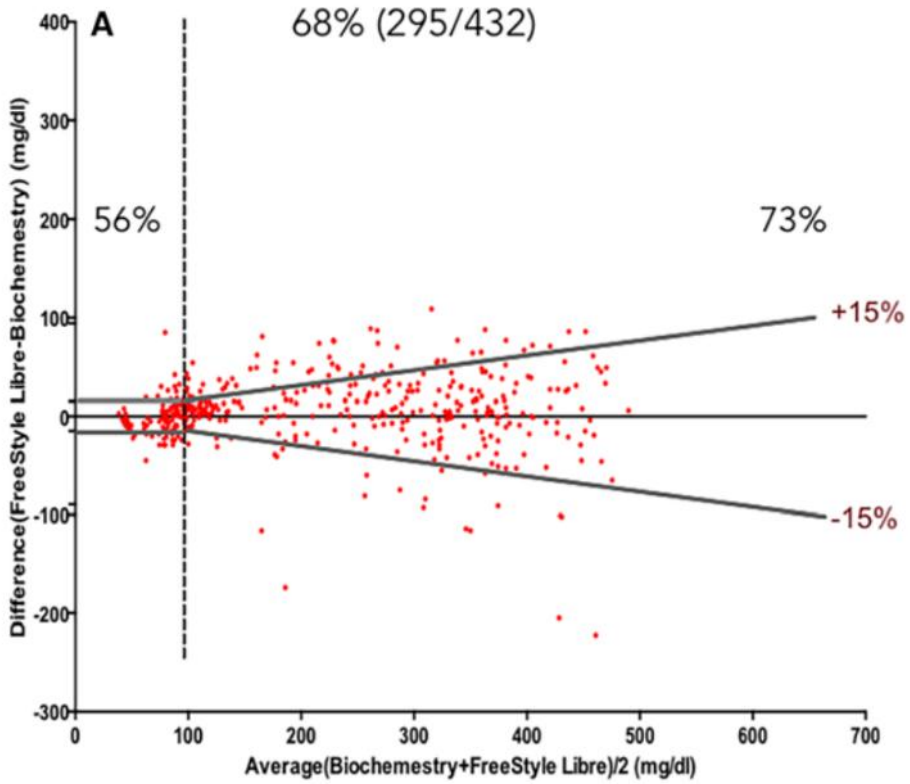
- dynamic relationship between glucose concentration in the plasma and ISF
- changes in ISF glucose concentrations lag behind changes in blood glucose concentrations
  - 5–12 minutes

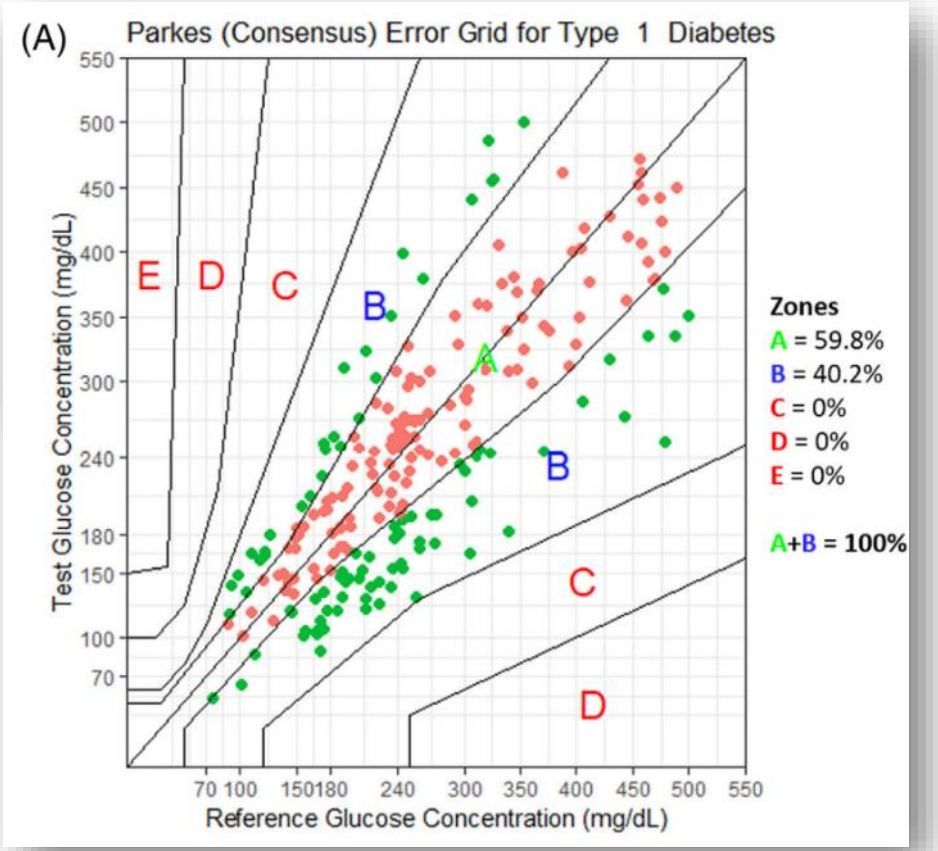
“CGMS measure skin glucose”

Journal of Veterinary Internal Medicine
Open Access
ACVIM American College of Veterinary Internal Medicine
J Vet Intern Med 2016

Accuracy of a Flash Glucose Monitoring System in Diabetic Dogs

S. Corradini, B. Pilosio, F. Dondi, G. Linari, S. Testa, F. Brugnoli, P. Gianella, M. Pietra, and F. Fracassi





DOI: 10.1111/jvim.15657

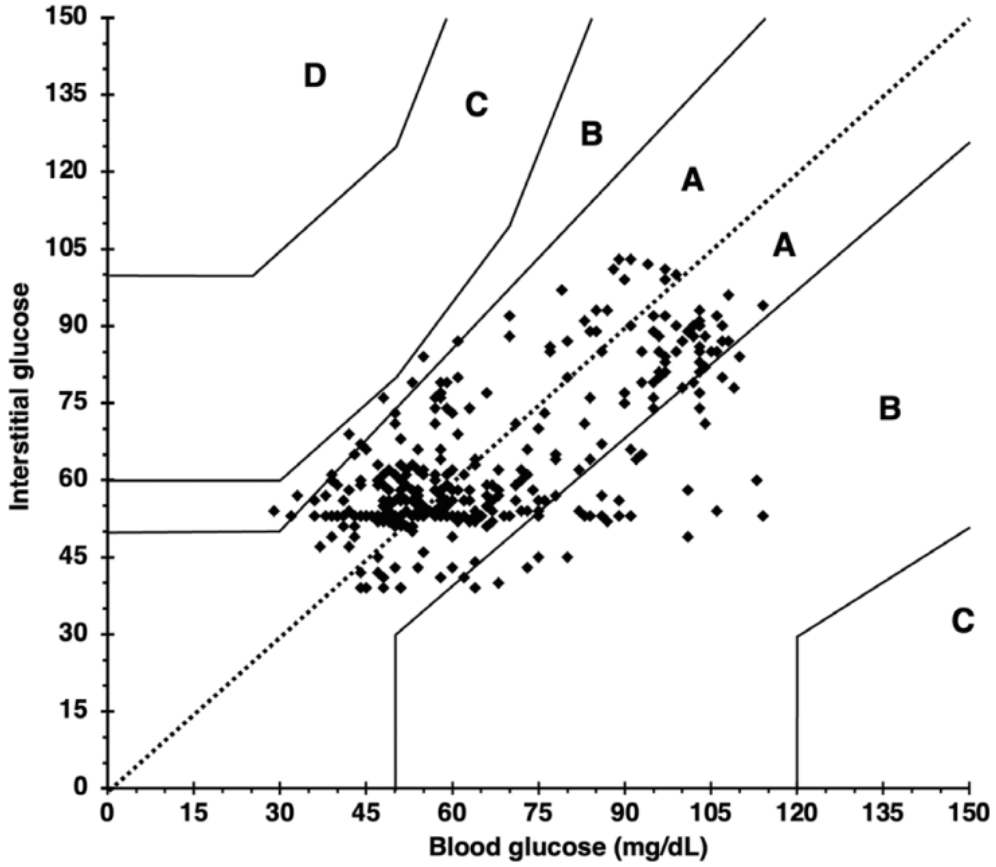
STANDARD ARTICLE

Journal of Veterinary Internal Medicine
Open Access
ACVIM American College of Veterinary Internal Medicine

Accuracy of a flash glucose monitoring system in dogs with diabetic ketoacidosis

Eleonora Malerba[1] | Chiara Cattani[1] | Francesca Del Baldo[1] | Gaia Carotenuto[1] | Sara Corradini[1] | Stefania Golinelli[1] | Ignazio Drudi[2] | Federico Fracassi[1]

Are the results accurate?



DOI: 10.1111/jvim.16820

STANDARD ARTICLE

Journal of Veterinary Internal Medicine Open Access

ACVIM American College of Veterinary Internal Medicine

Assessment of the FreeStyle Libre 2 interstitial glucose monitor in hypo- and euglycemic cats

Alisa S. Berg | Chiquitha D. Crews | Christopher Adin | Adriana Alfonso-Castro | Susan B. Hill | Jocelyn Mott | Chen Gilor

At normal and low concentrations

Tendency to underestimate (blood glucose is higher than skin glucose)

Except when very low (<3 mmol/l) when overestimates

8.5 % were in group B

Safety and adverse reactions?

Very few risks

Single case of pneumothorax reported

Main adverse reaction is skin inflammation ≈ 40%

Mild and self resolving when sensor removed

Rarely

skin erosions, abscess formation

Limits

Lower limit (both) 2.0-2.2mmol/L

Upper (Freestyle) display 19.4-22.2 mmol/L

Upper (Freestyle) recorded data 27.7 mmol/L)

Upper (InSight) 42 mmol/l

Owner's perspectives

- >80% CGMS less stressful than BG curves
- 92% reported better control
- Cost and keeping sensor attached main concerns
- Cats tolerated sensors less well

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How should they be fitted

- Sites
  - Flat immobile inaccessible area with 4 mm of tissue
  - Lateral neck, interscapular, flank, lumbar
- Select site
  - fresh area, no skin lesions
- Clip and clean skin thoroughly
- Deploy sensor and detach deployment device
  - To glue or not to glue
- Do not cover with occlusive dressing

When should they be used?

- Use for
  - Initial stabilization
    - Allows more rapid / aggressive insulin management
  - Poor response to insulin
  - Marked day-day or within day variability
  - Cats entering diabetic remission
- Less valuable
  - When blood glucose is available anyway
  - Emergencies – DKA, hypoglycaemia

When may CGMS be unreliable?

- *Theoretically* 14 days but
  - Most patients expect 7-10 days of useable data
  - Will not work in a small percentage of patients
- Unreliable
  - Thin skin (<5mm)
  - anaesthetized patients,
  - dehydrated animals
  - postprandial hyperglycaemia
  - DKA ? (conflict between data and personal experience)
- Lag period
  - Important when blood glucose changing rapidly

Del Baldo *et al* 2021 Animals (Basel); Shea & Hess 2021 JVIM

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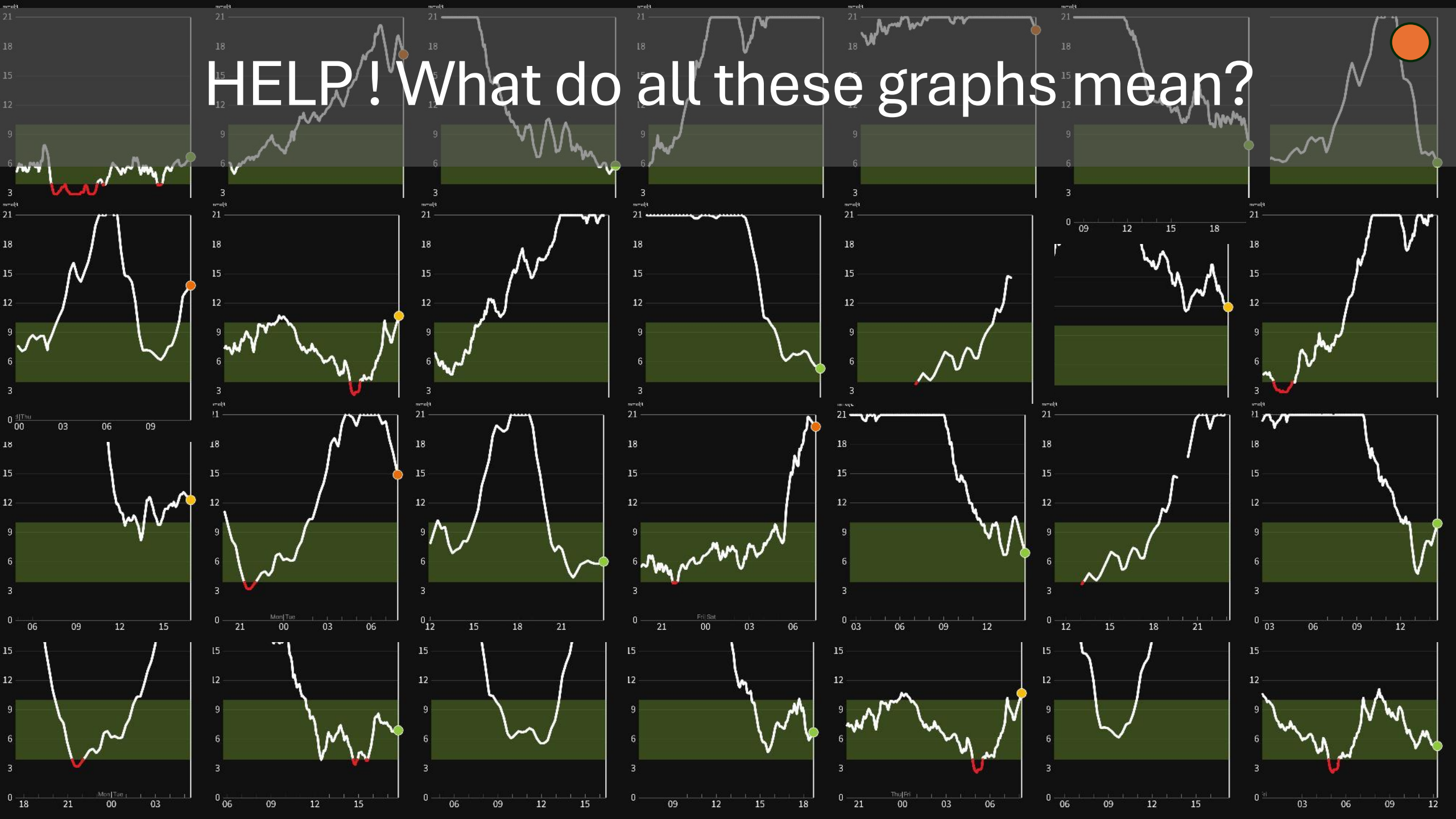
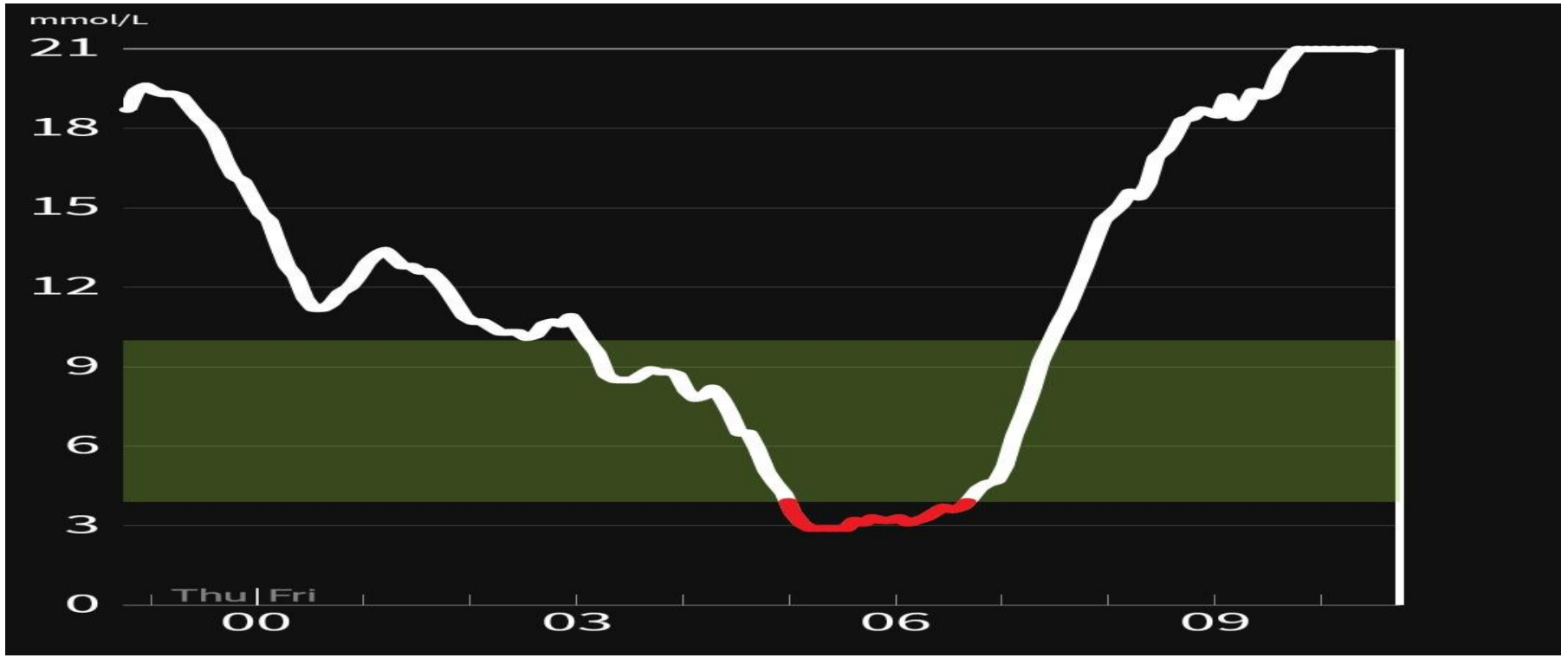
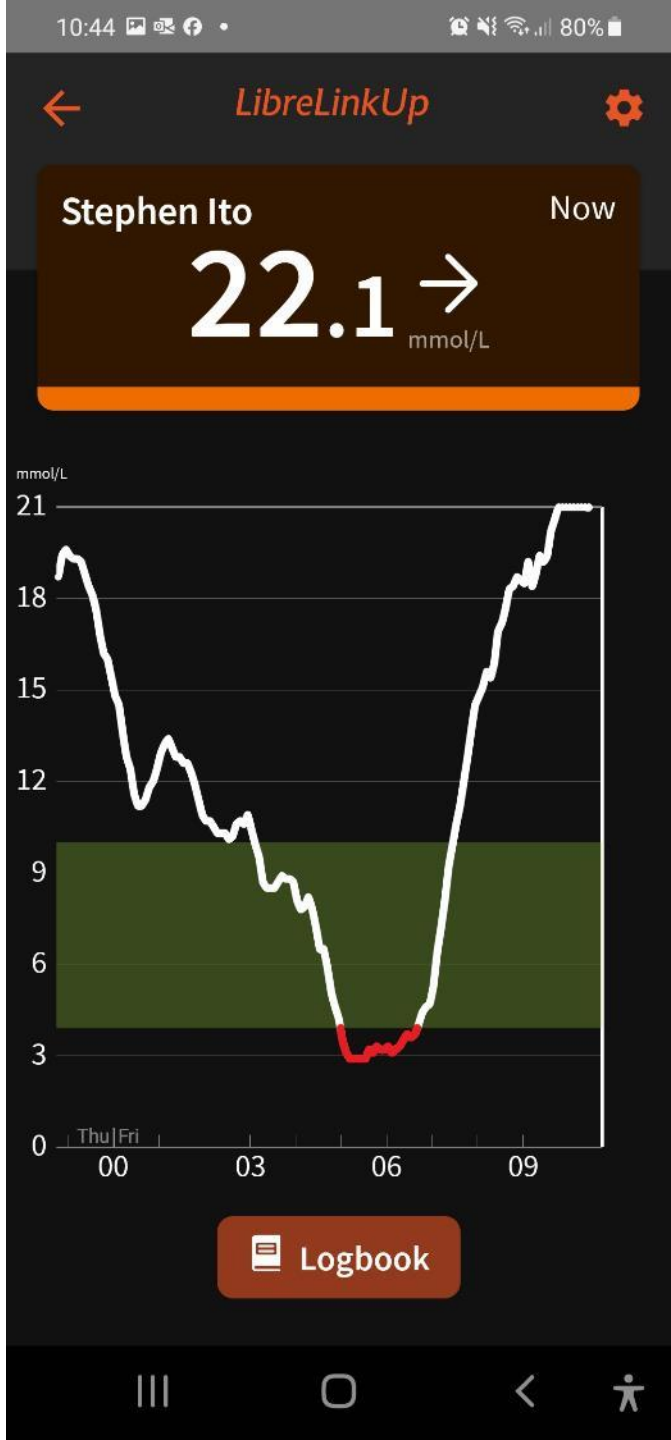
HELP ! What do all these graphs mean?



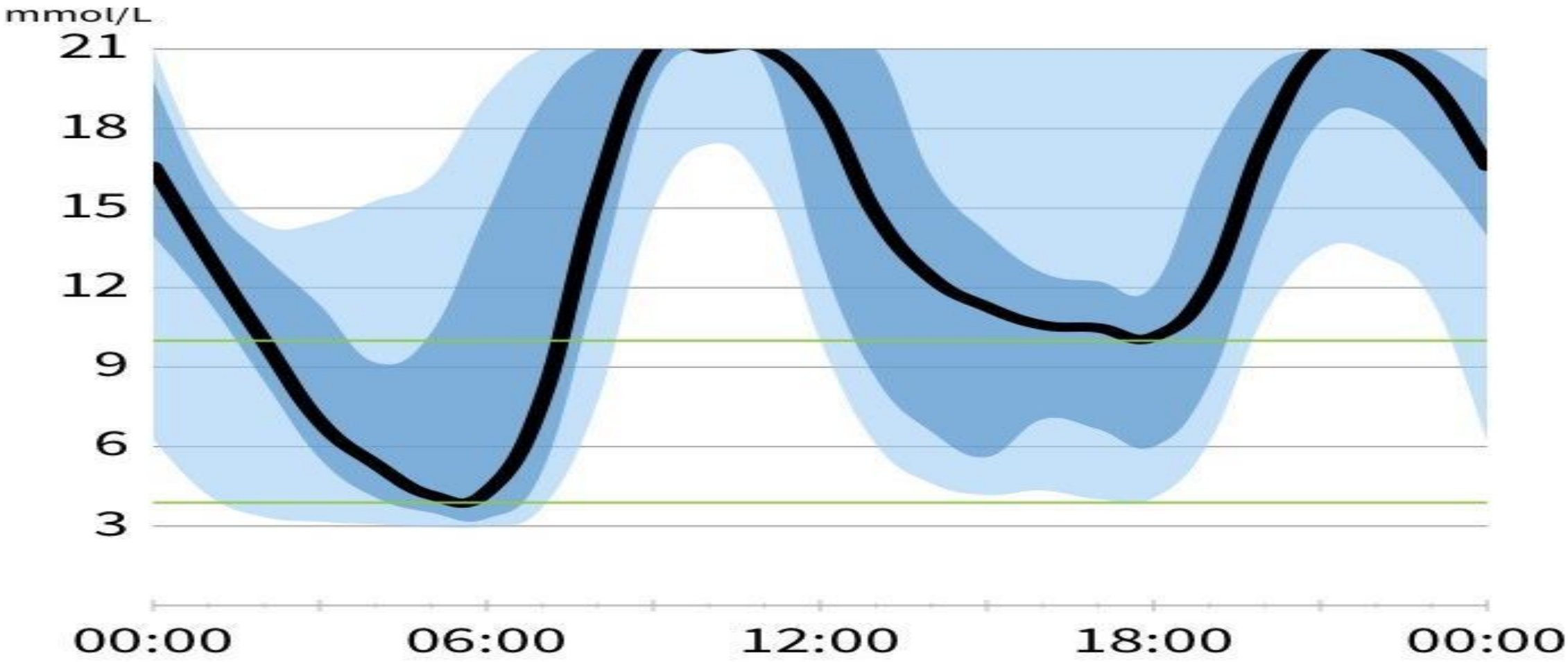
The orientation problem

- OH NO! It’s the dreaded Somogyi overswing……



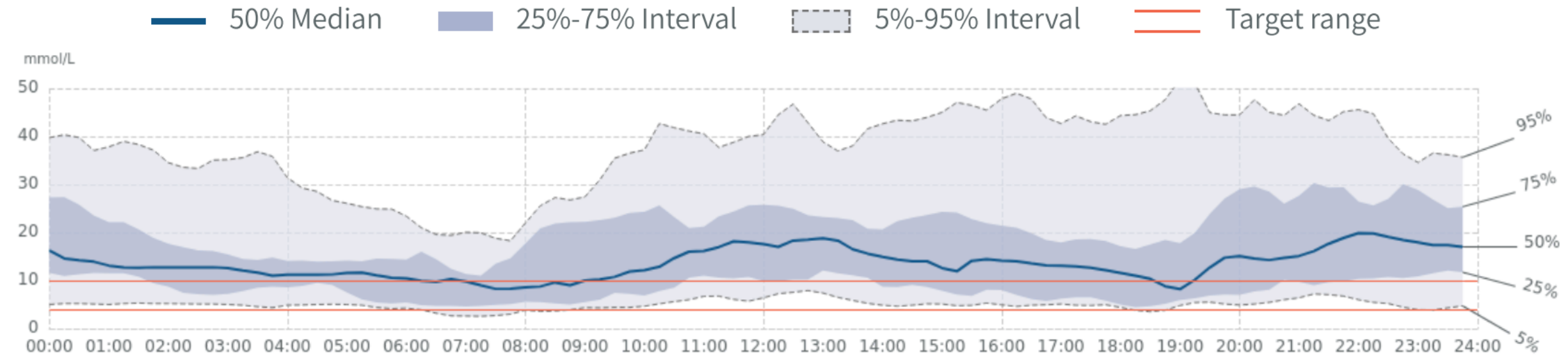


What we need to look at



Ambulatory Glucose Profile (AGP)

AGP is a summary of glucose values from the report period, with median (50%) and other percentiles shown as if they occurred in a single day

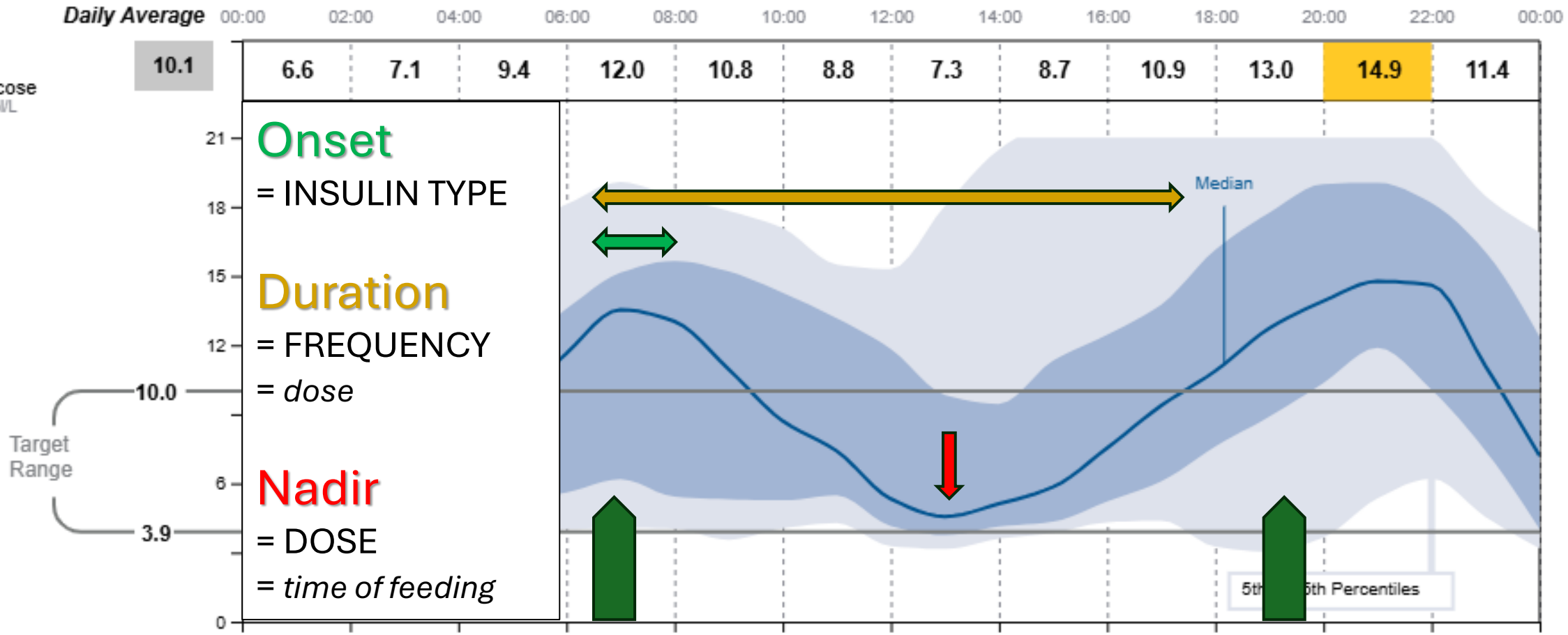


Daily Patterns

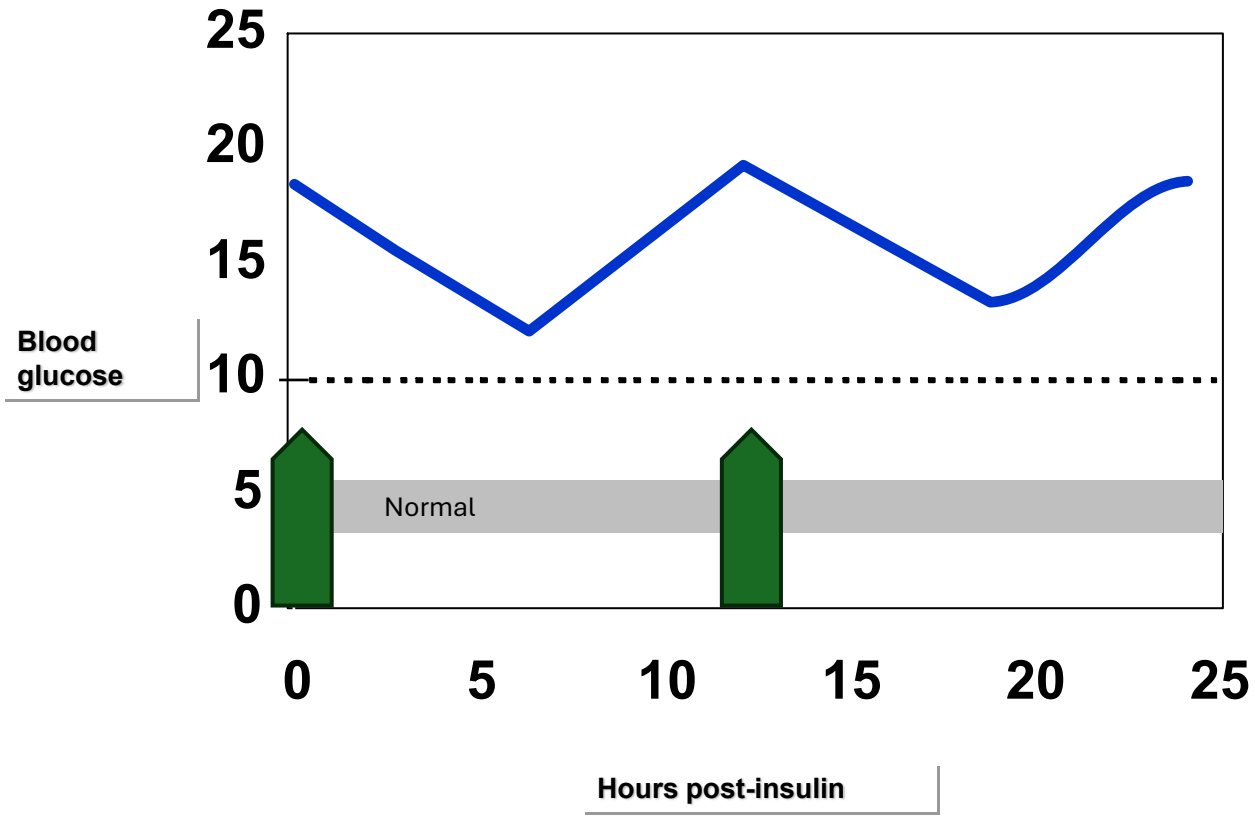
23 February 2025 - 8 March 2025 (14 Days)

= insulin + food

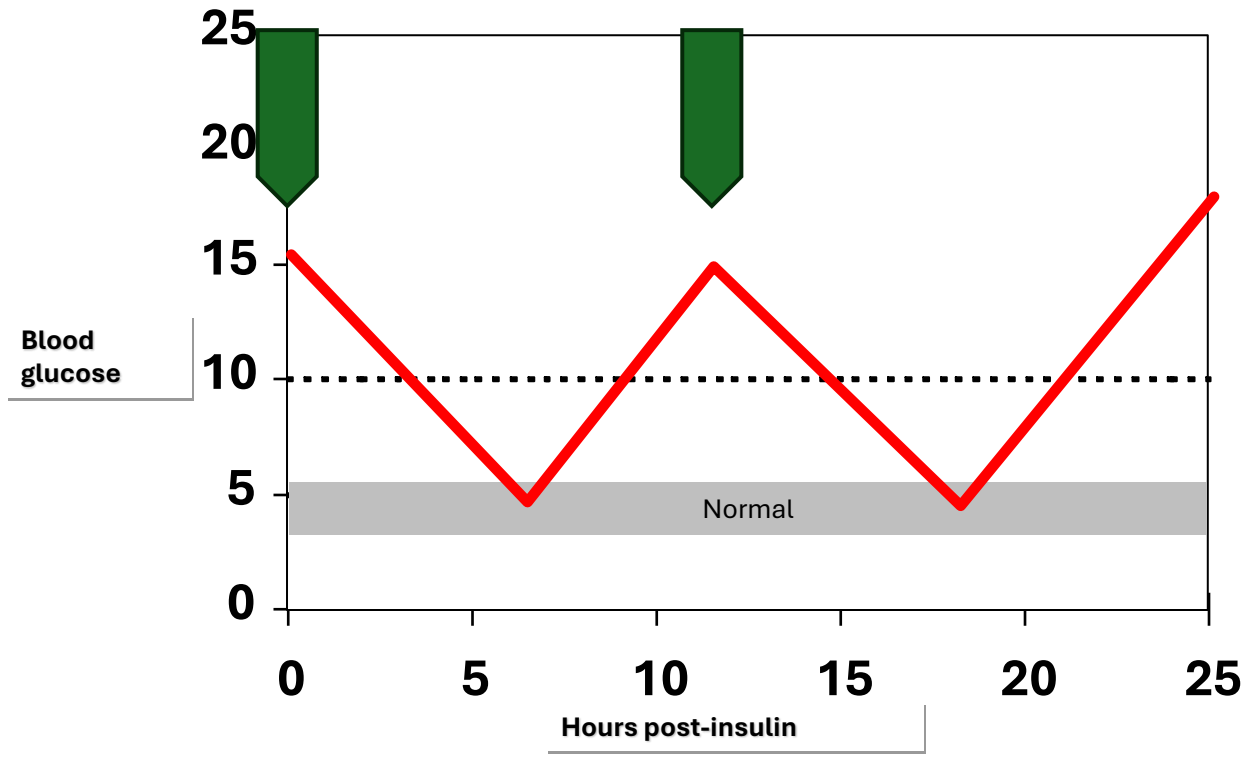
LibreView



Insufficient insulin



Rapid insulin use/metabolism

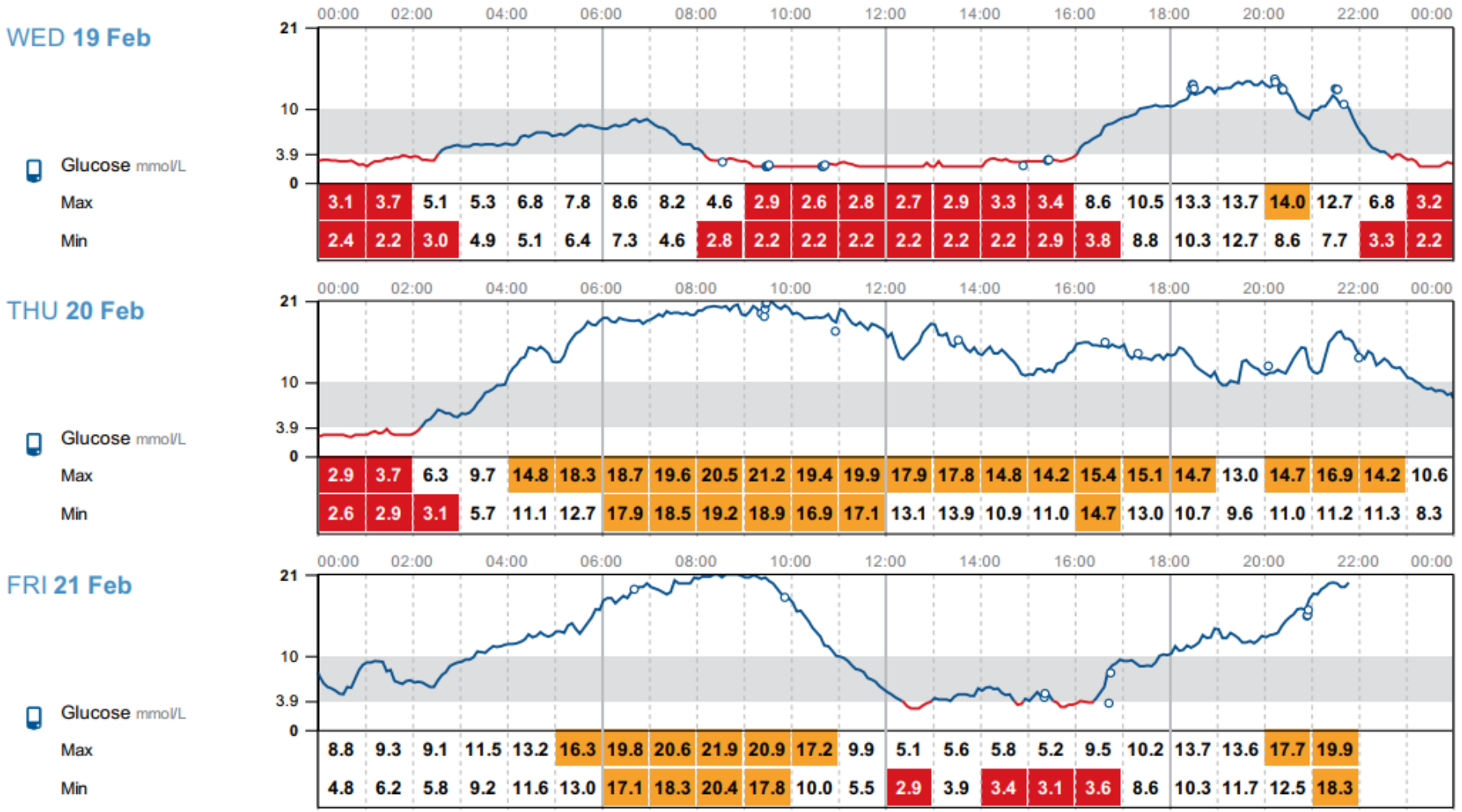


What we need to look at 2

Daily Log

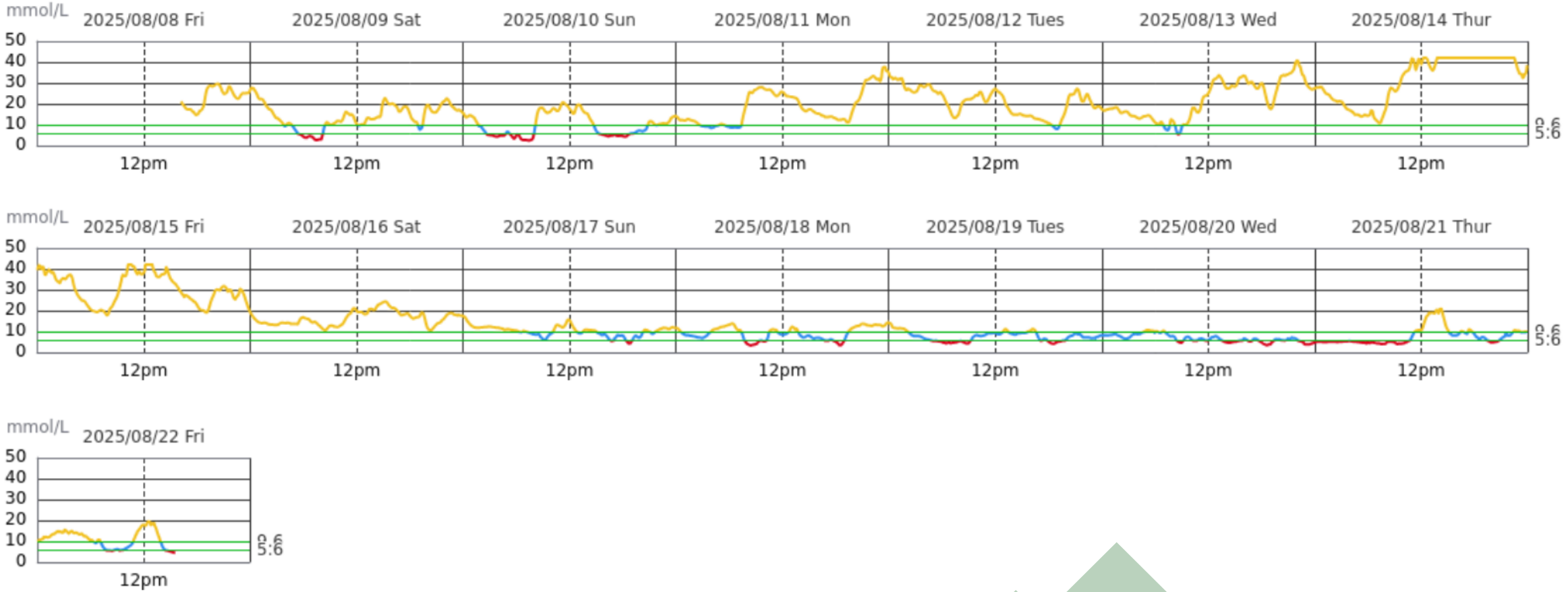
12 December 2024 - 11 March 2025 (90 Days)

LibreView



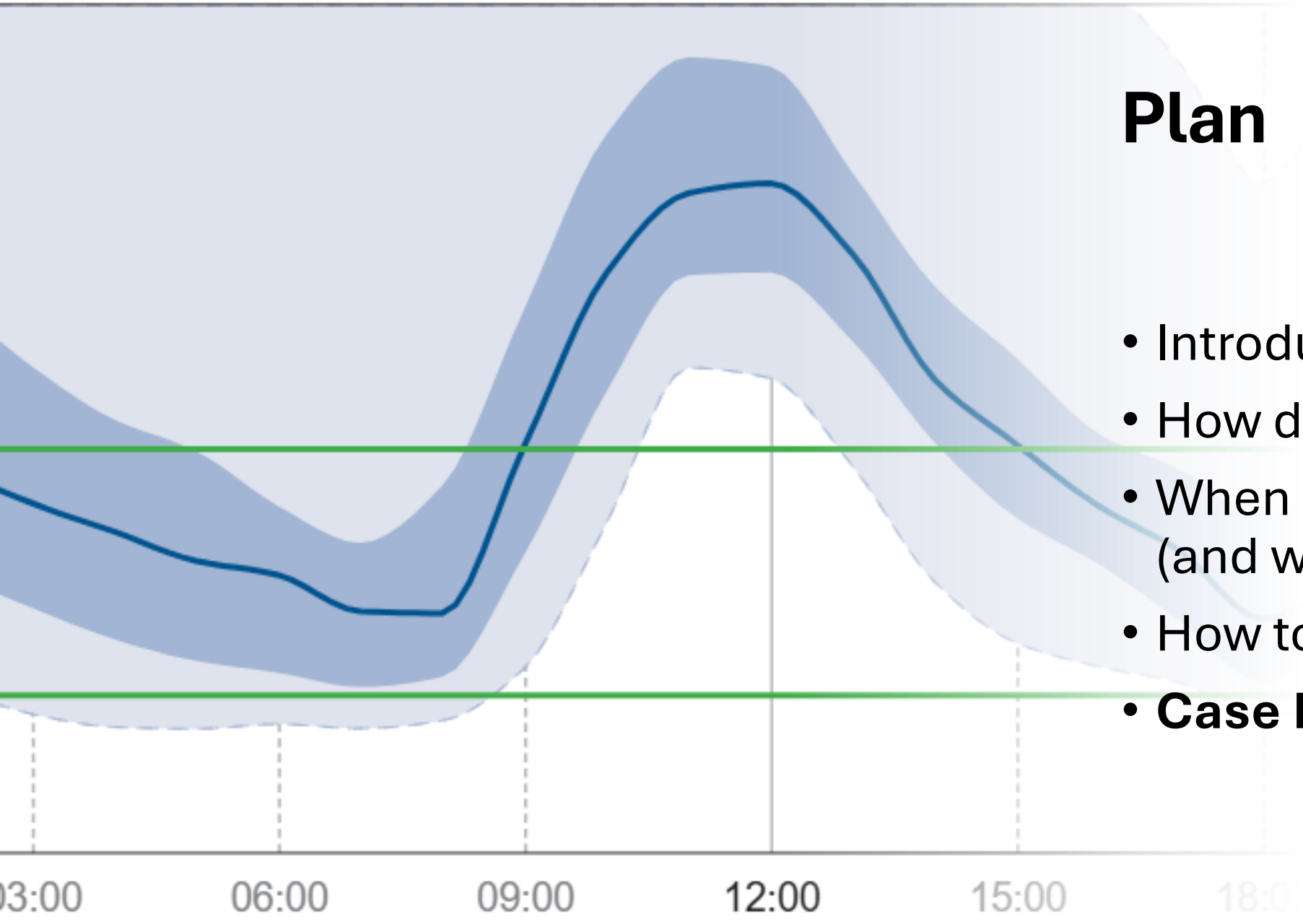
Daily Glucose Profile

Each daily profile represents a midnight-to-midnight period.



Home monitoring

Date	Time	Urine test	Food	Water	Insulin	Weight	Notes
12/8	0800	++++	++++	++++	3 iu	6 kg	Ketones
13/8	0800	++++	+++	++++	3 iu		
14/8	0800	++++	++++	++++	3 iu		
15/8	0800	+++	++++	+++	3 iu		
16/8	0800	++++	++++	++++	3 iu		Ketones
17/8	0800	++++	++++	++++	3 iu		
18/8	0800	+++	++	+++	3 iu		Ketones



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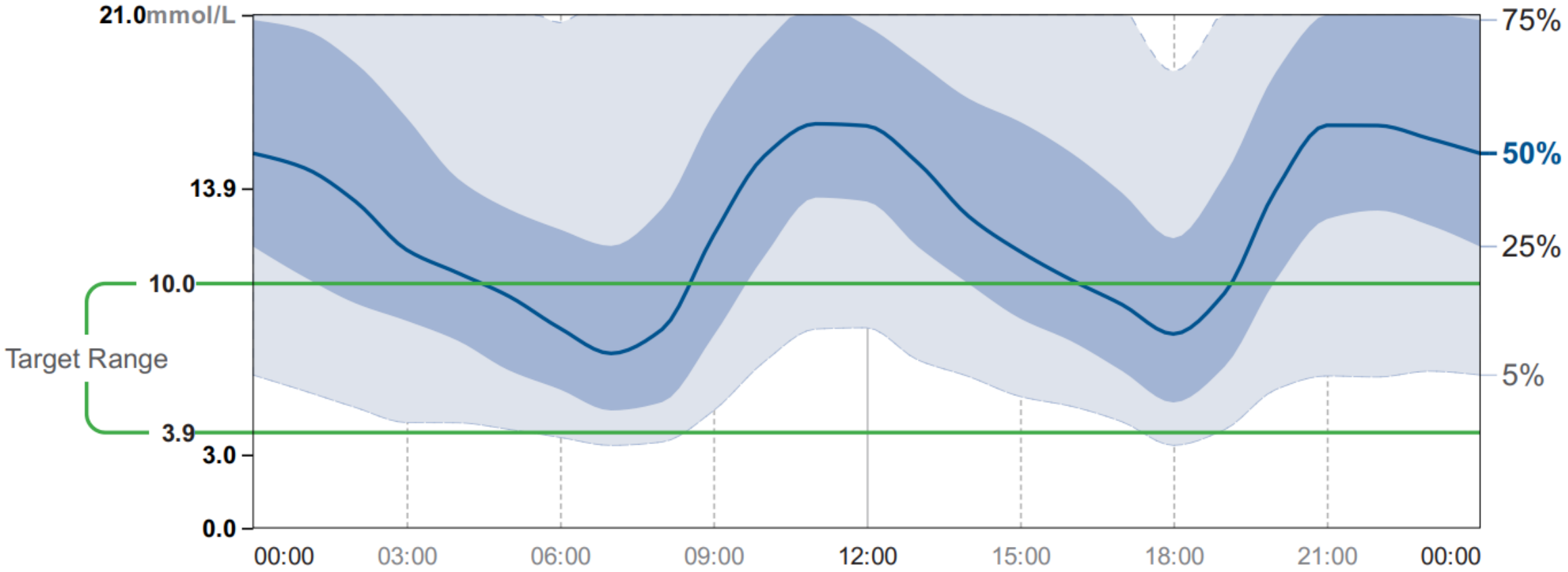
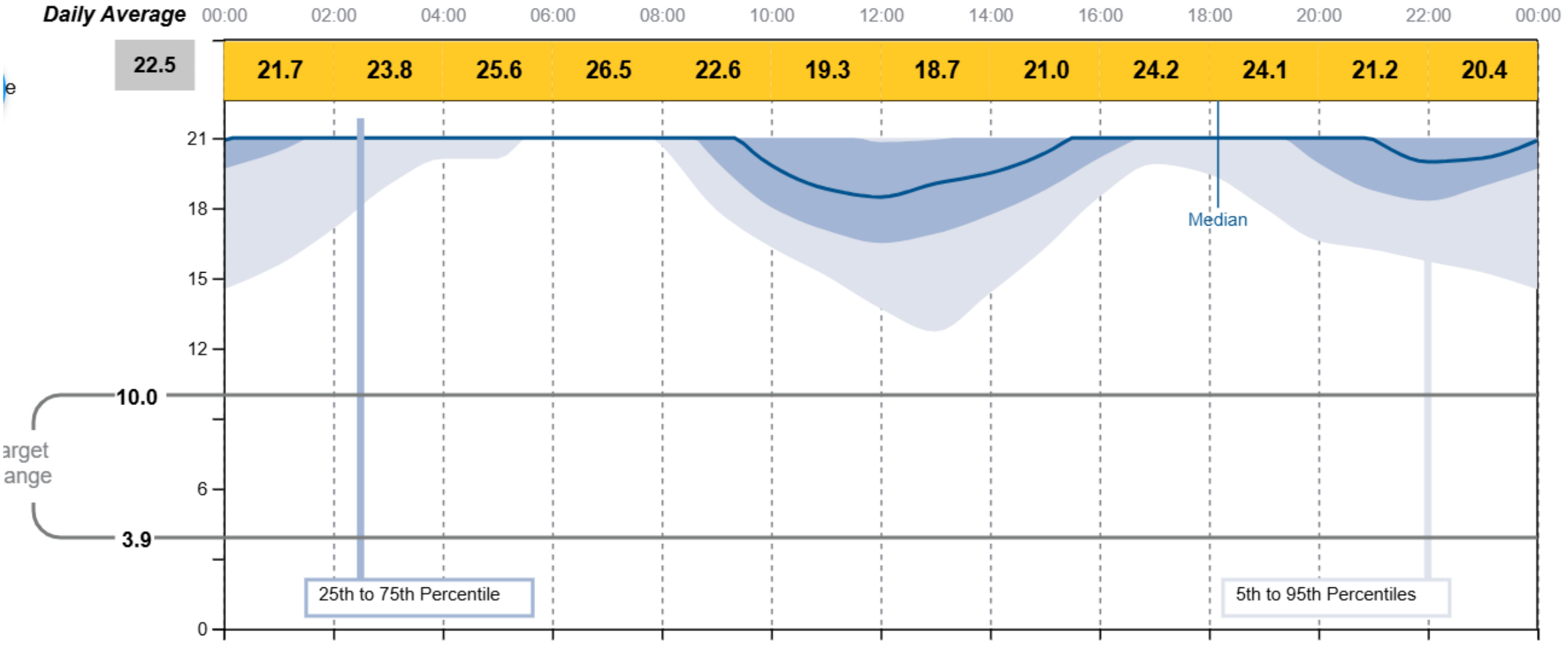
- **Case Examples**

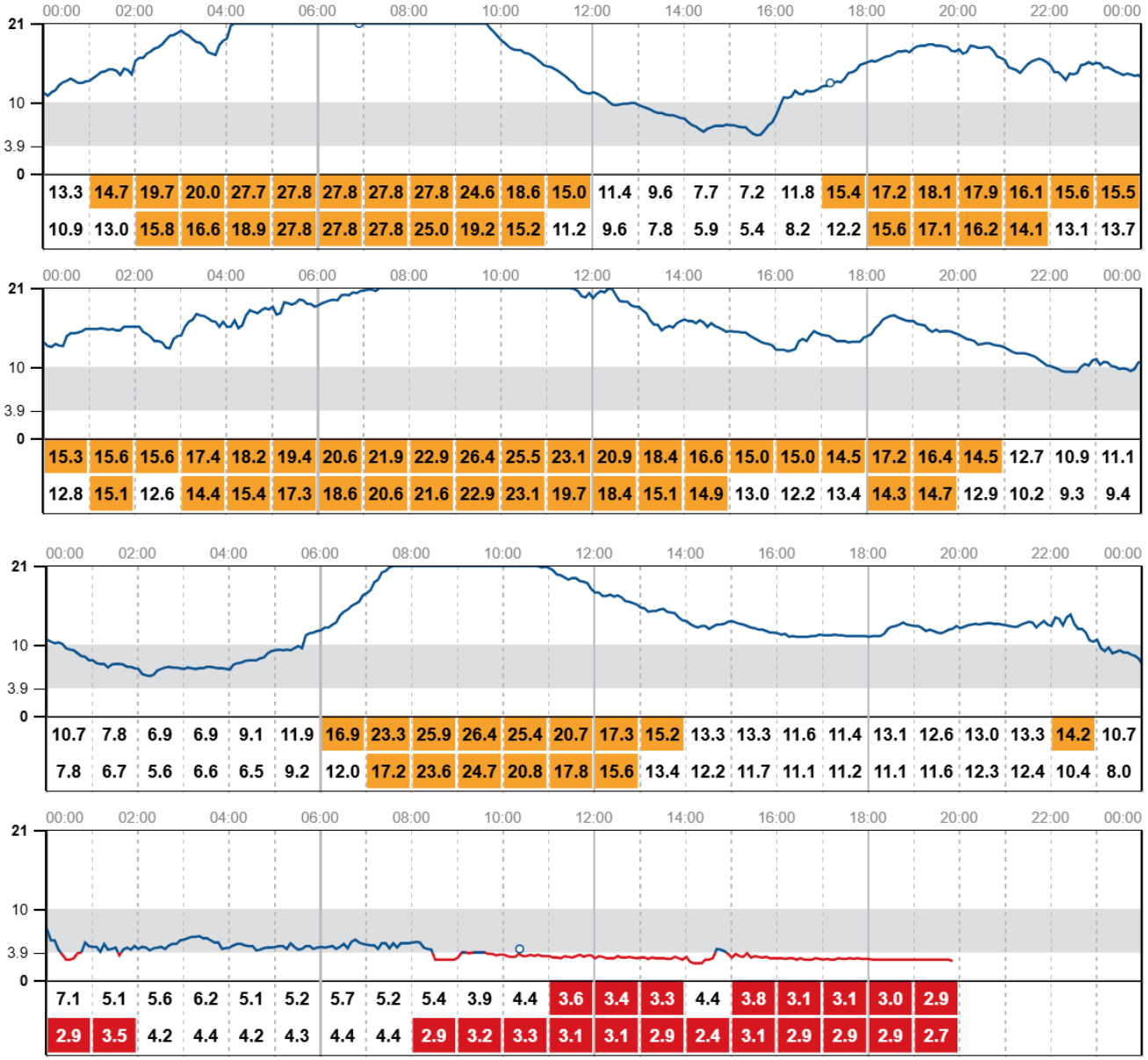
8 year old typical insulin treated diabetic dog, who is on PZI q12h



Insulin resistance (4kg acromegalic cat on 12 units BID Prozinc; IGF >2000)



Diabetic Remission? (22 iu BID Prozinc)



Olly

Velagliflozin

Blood glucose = ?

Daily Log

12 December 2024 - 11 March 2025 (90 Days)

LibreView

SUN **9 Mar**

Glucose mmol/L
Max
Min

00:00	02:00	04:00	06:00	08:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00	00:00
6.2	5.1	5.5	6.0	6.3	5.5	6.1	5.2	6.1	5.7	5.7	4.8	4.7	6.0	4.6	4.3	3.8	4.7	5.6	5.2	5.8	5.2	4.4	3.5
3.0	4.3	3.9	4.9	4.9	4.7	5.0	4.3	5.3	5.0	4.6	3.1	4.1	3.7	2.9	3.3	3.3	2.9	3.6	3.6	4.2	3.1	3.3	2.3

MON **10 Mar**

Glucose mmol/L
Max
Min

00:00	02:00	04:00	06:00	08:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00	00:00
3.0	3.1	2.8	2.9	4.3	5.3	4.9	4.7	4.4	5.1	5.5	3.9	4.2	5.0	3.2	2.3	2.9	4.3	4.6	4.1	3.4	3.9	3.2	2.9
2.7	2.2	2.2	2.2	2.2	3.9	4.0	3.6	3.2	3.6	2.9	2.9	2.2	2.9	2.2	2.2	2.2	2.2	3.4	3.3	2.9	2.2	2.2	2.2

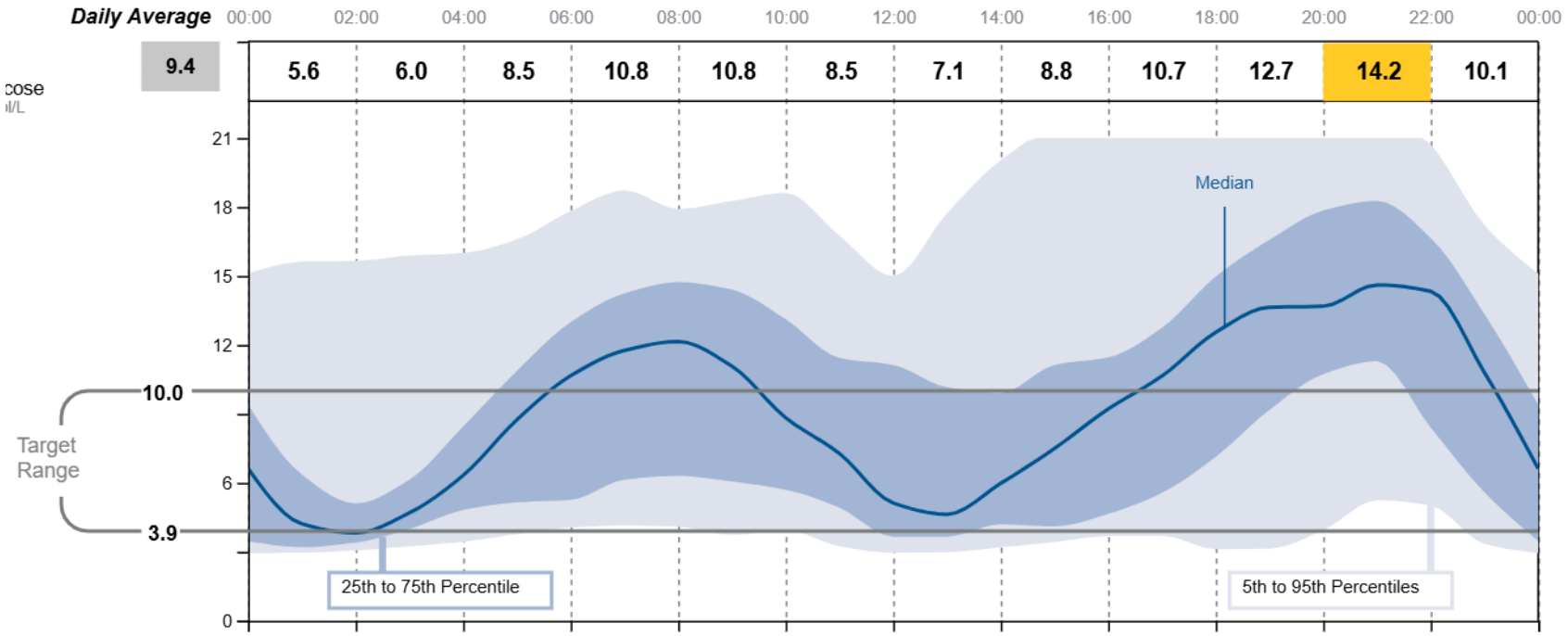
TUE **11 Mar**

Glucose mmol/L
Max
Min

00:00	02:00	04:00	06:00	08:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00	00:00
2.9	2.9	2.9	2.9	3.0	3.0	3.8	4.0	4.3	3.1	4.1	3.6	4.6	2.9
2.7	2.2	2.2	2.4	2.2	2.6	2.9	2.2	2.9	2.9	2.2	2.8	2.9	2.5

Howard – 9.2 kg , 11 units PZI BID

Not acromegalic
Not hypercortisolemic
Not hypothyroid



Summary

- CGMS are here to stay
  - cheaper and better than blood glucose curves in most cases
  - many owners love them!
- Interpretation
  - Look at the patient first, home records second, then …
  - Average (AGP), then at the individual days
  - Ask for help
    - but summarize salient details

Thanks for listening!

Discussion and Questions