Insulin Optimisation in Type1 diabetes (and non-T1):

Why it's 'Glucose AND Insulin' and not just 'Glucose'

Me

- GP
- T1D 33 Years. 20 on conventional, 13 on Keto
- Founder member of the Preventive Health Collaboration
- Medical Advisor to Keto-Live Centre, Switzerland
- Clinical Advisor to the Nutrition Network, S Africa.
- Contributing author to a position statement on Therapeutic Nutrition in T1 management USA.
- Bristol Medical School Let’s Go Keto! Contributing teacher



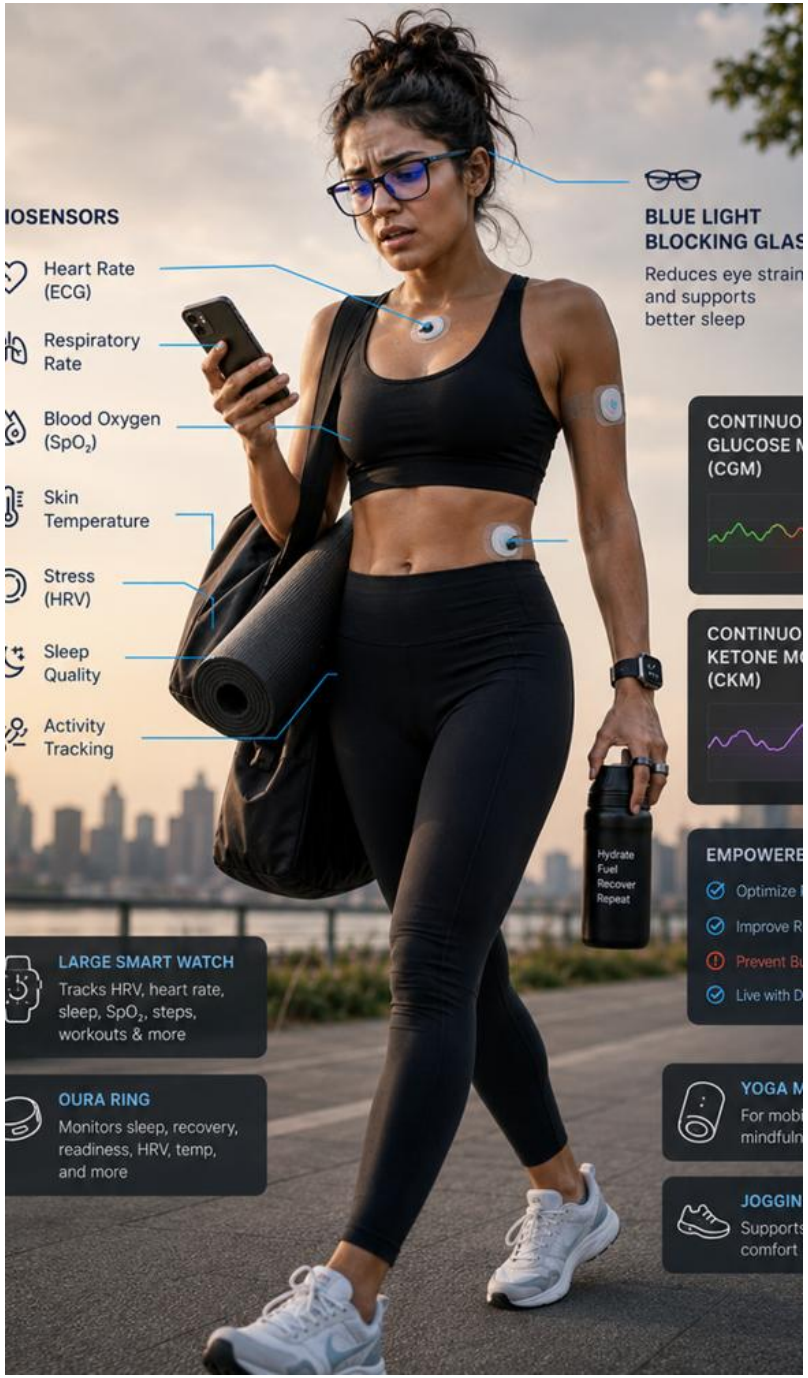











IOSENSORS
Heart Rate (ECG)
Respiratory Rate
Blood Oxygen (SpO_2)
Skin Temperature
Stress (HRV)
Sleep Quality
Activity Tracking
BLUE LIGHT BLOCKING GLAS
Reduces eye strain and supports better sleep
CONTINUO GLUCOSE M (CGM)
CONTINUO KETONE M (CKM)
EMPOWERE
Optimize
Improve R
Prevent Bu
Live with D
Hydrate Fuel Recover Repeat
LARGE SMART WATCH
Tracks HRV, heart rate, sleep, SpO_2, steps, workouts & more
OURA RING
Monitors sleep, recovery, readiness, HRV, temp, and more
YOGA M
For mobi mindfuln
JOGGIN
Supports comfort






Diabetes Clinic
SUPPORT • PREVENT • MANAGE • LIVE WELL
Managing Diabetes Together
Regular checks
Healthy eating
Stay active
Take medication
Prevent complications
Reception
Early Care Brighter Tomorrows
Diabetes Care For A Healthier Tomorrow
Eyes
Heart
Kidneys
Feet
Better Lives
72
98
16
Healthy Living with Diabetes
Foot Care Matters
Kidney Health
Heart Health After Diabetes
Eye Health Protect Your Vision

In E+W, 60% of people living with T1D are losing 100 days of life every year.

(HbA1c>58mmol/mol)

Mean HbA1c T1D E+W is? **70mmol/mol**

Heald AH, Stedman M, Davies M, et al. (2020).Estimating life years lost to diabetes: outcomes from analysis of National Diabetes Audit and Office of National Statistics data. Cardiovascular Endocrinology & Metabolism, 9(4), 183–185.

Publication, Part of National Diabetes Audit

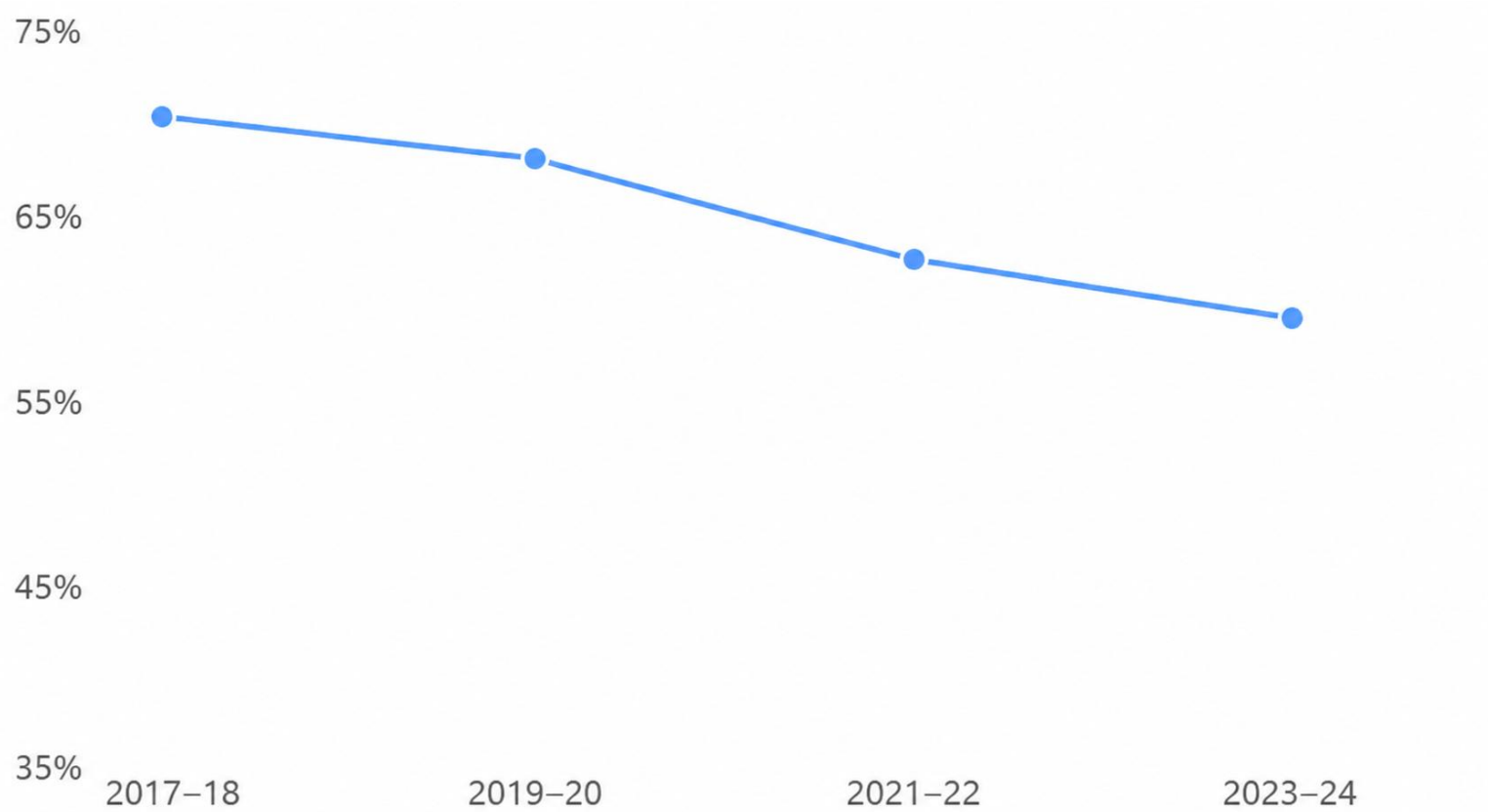
Complications and Mortality Outcomes dashboard, 2009-2023

Audit, Survey, Other reports and statistics

Publication Date:	14 Nov 2024
Geographic Coverage:	England, Wales
Geographical Granularity:	NHS Trusts, GP practices, Integrated Care Boards, Regions
Date Range:	01 Jan 2009 to 31 Dec 2023

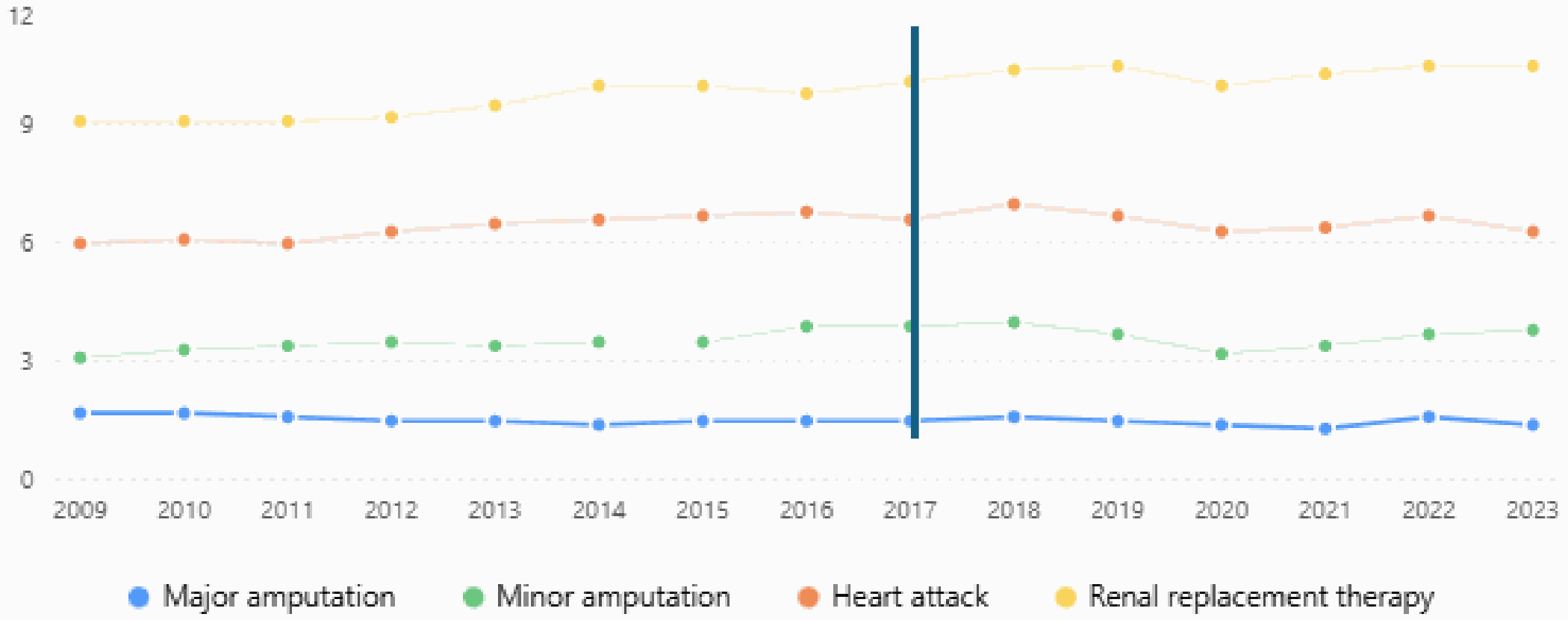
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% of population of T1 with HbA1c <58 mmol/mol (7.5%)



Amputations, heart attacks and renal replacement therapy

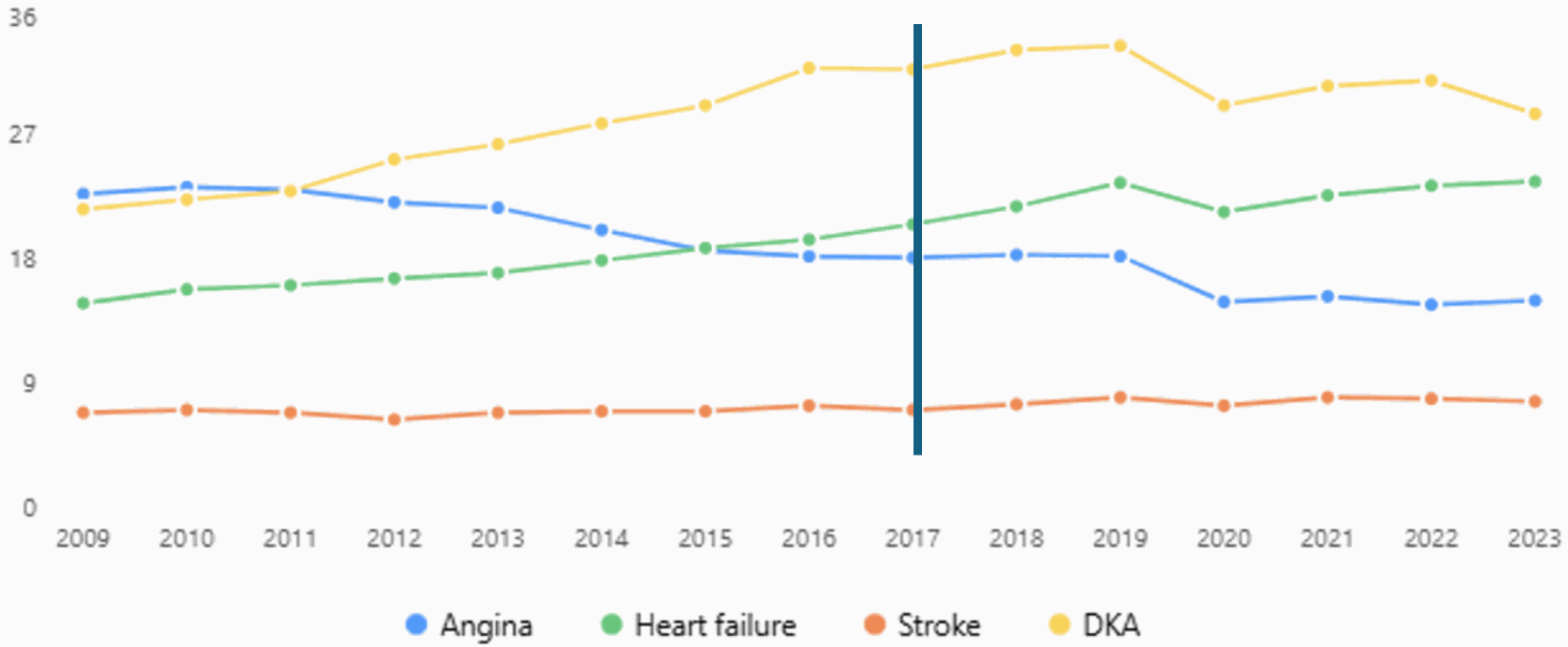
England, type 1 diabetes. Annual people affected per 1,000 people in the audit cohort.



NHS England NDA 2009–2023. Crude rates, not adjusted for age. Renal replacement therapy includes dialysis and transplant procedures.

Other hospital-recorded complications

England, type 1 diabetes. Annual people affected per 1,000 people in the audit cohort.



NHS England NDA 2009–2023. DKA means diabetic ketoacidosis. These are unadjusted rates.

What is Type 1 Diabetes?

Insufficient insulin to maintain optimal blood glucose (autoimmune)

Hormone Replacement Therapy.

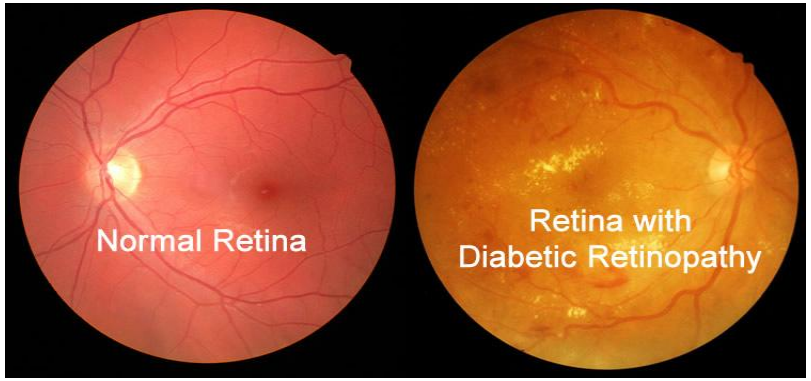
400,000 people in UK with T1D,

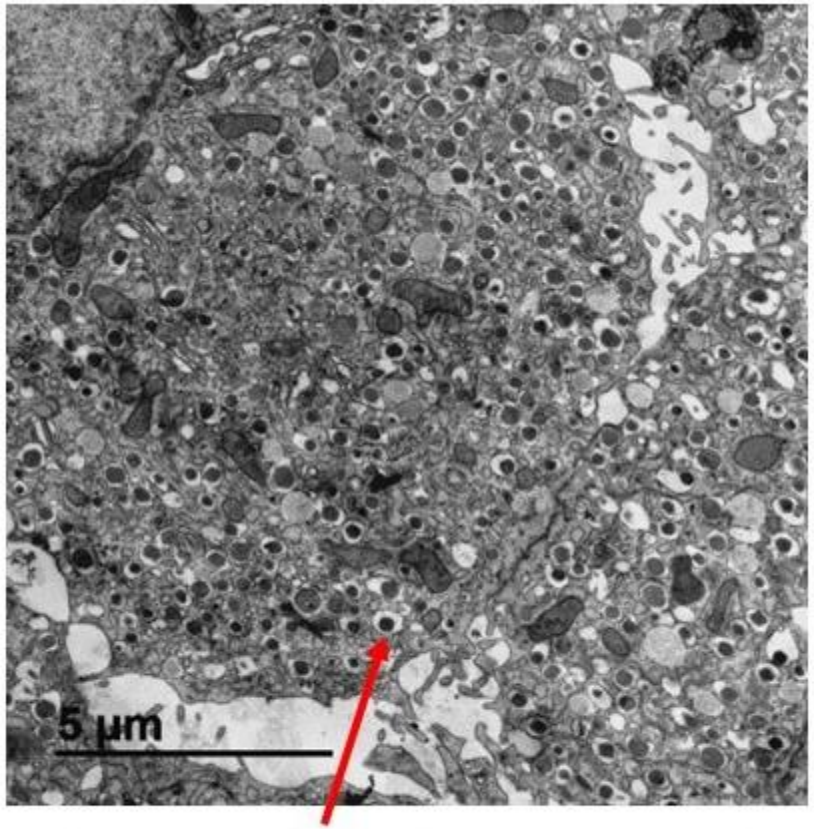
400,000 different management strategies.

Insulin and dietary requirements change throughout life.

Auto-immune diseases are unpredictable in outcomes.

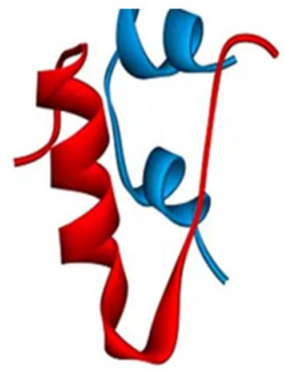


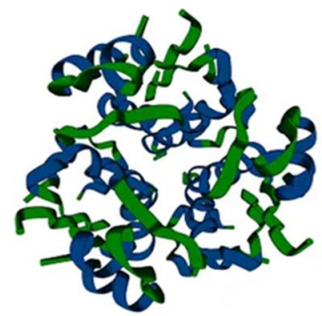


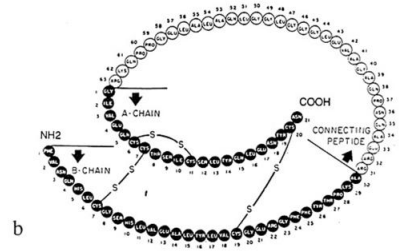


insulin granule = “storage vesicle”

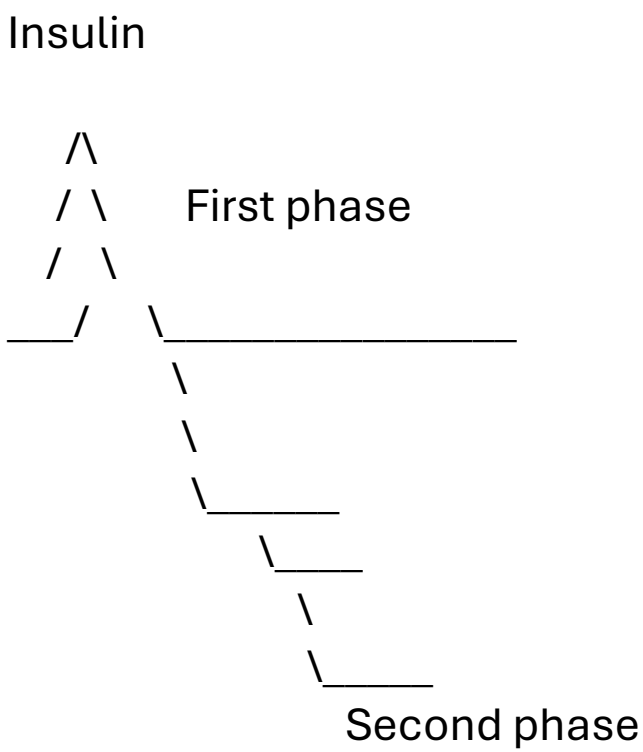
Insulin







b


Insulin
First phase
Second phase
Time

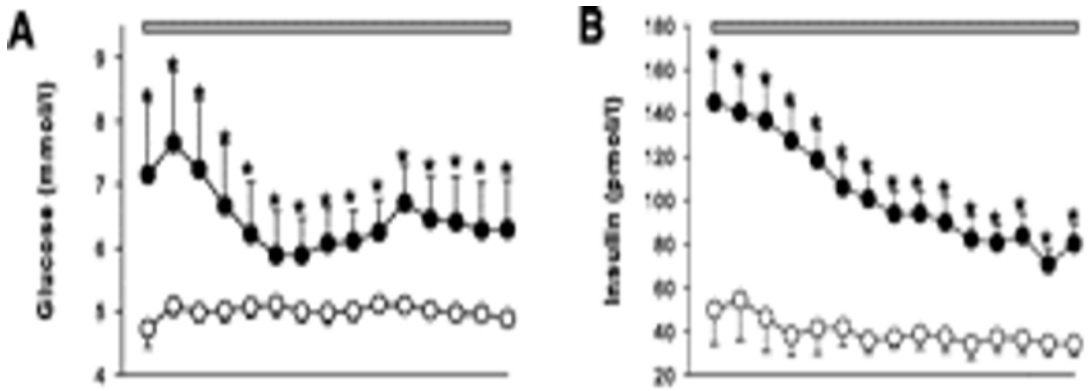
Where T1 differ from non-T1

Portal Insulin.

Peripheral (arterial) Insulin

In someone without T1 P/A is 3:1
In someone with T1 P/A is less than 1 post prandially.

Because of this, you require more insulin than physiological to achieve glucose control



In response to exogenous insulin, study subjects had marked elevations in insulin concentrations compared to controls. ….insulin.. concentration was 3.5-fold higher in diabetics than non-diabetics.

…..during the 24 hr of study, no subject had a profile that mimicked that observed in non-diabetic subjects.

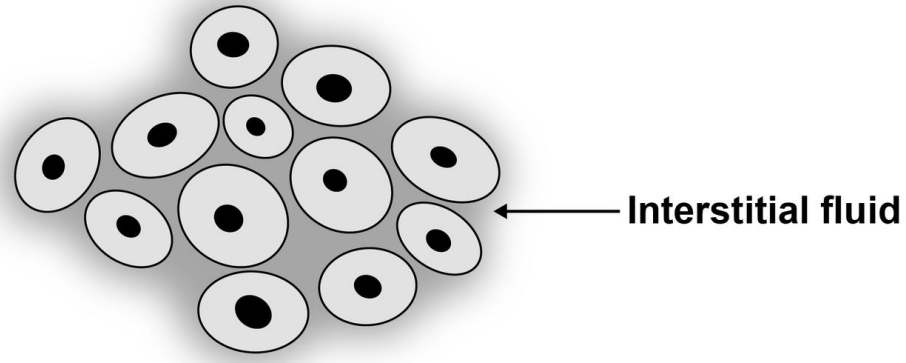
These data emphasize the difficulty in establishing normal patterns of insulin among diabetic subjects on conventional subcutaneous insulin therapy.

https://www.metabolismjournal.com/article/0026-0495(82)90116-0/abstract

Timing of Insulin

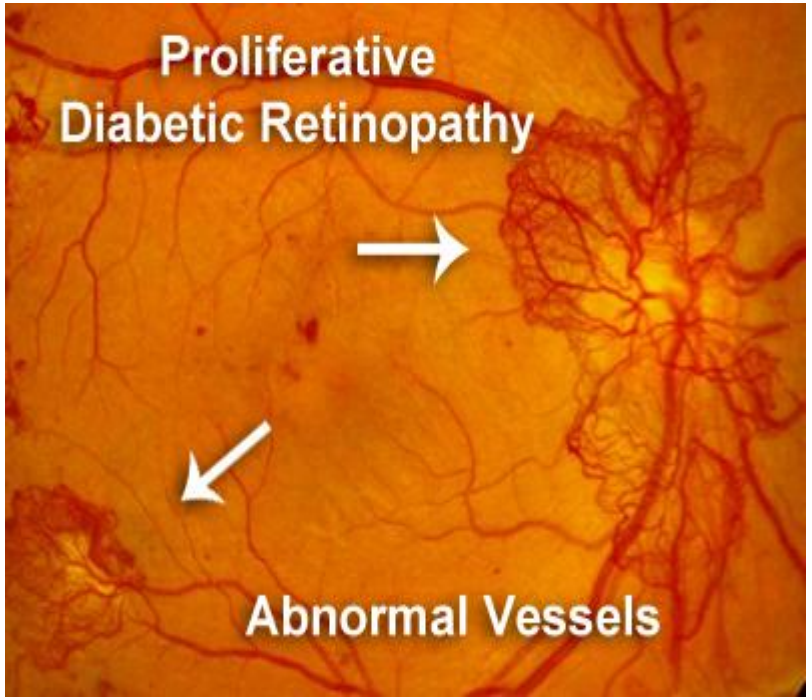
Feature	Biological (Endogenous)	Synthetic (Injected)
Release pattern	Two-phase: immediate, then pulsatile	
Timing	Bioactive for 4–12 minutes	
Source	Secreted by the pancreas	
Primary circulation	Portal circulation	
Hormonal regulation	Finely balanced with other hormones	

How does insulin work?



Interstitial fluid bathes cells in nutrients and signalling molecules — the cells choose their fuel from what is available



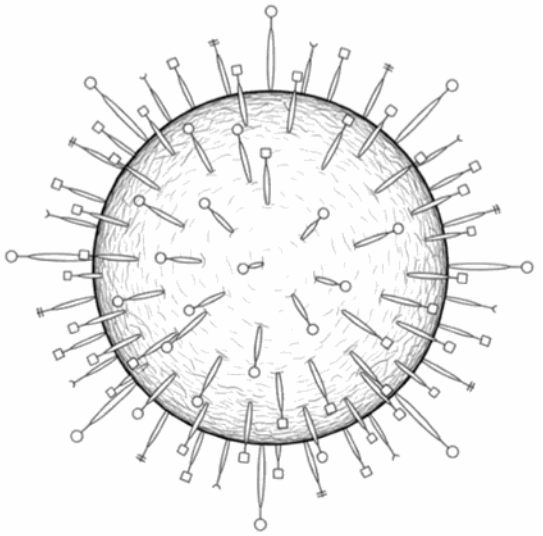


‘Miracle’: Trapped man rescued eight days after Venezuela earthquakes



Interaction with other hormones

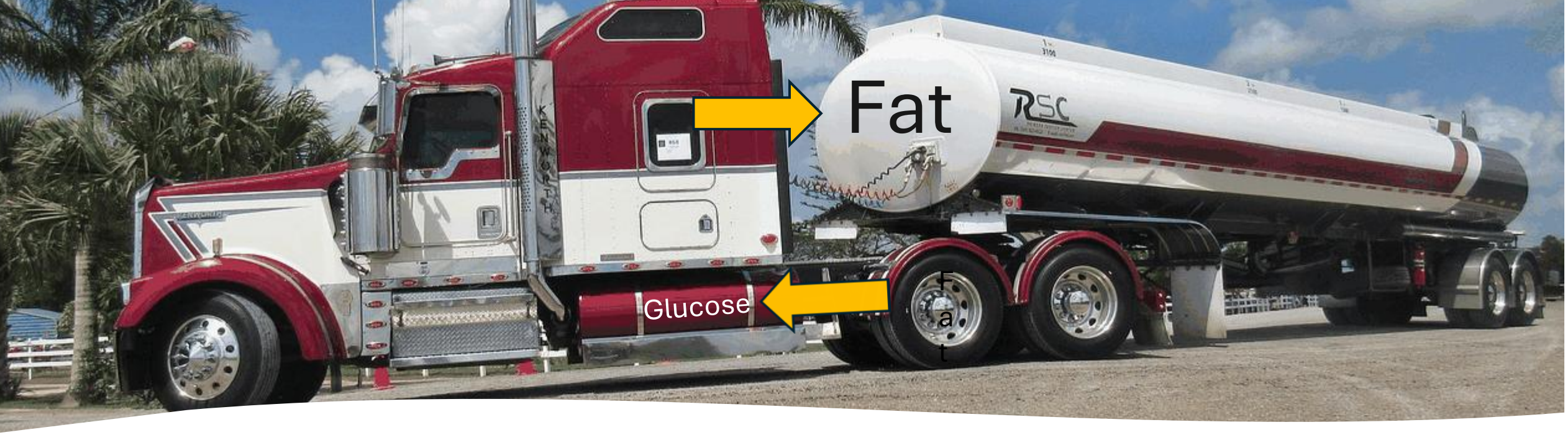
Glucagon
Adrenaline
Cortisol
Growth Hormone
Leptin
Ghrelin
Dopamine
Progesterone
Oestrogen
Testosterone
Gut Peptides
Thyroxine



Concerns associated with chronic hyperinsulinaemia

- **Weight gain and fat storage:** Insulin promotes fat storage and suppresses lipolysis, making it harder to mobilise stored fat for energy.
- **Insulin resistance:** Persistently elevated insulin can contribute to reduced insulin sensitivity, potentially creating a cycle of increasing insulin requirements.
- **Cardiovascular disease**: Hyperinsulinaemia is associated with hypertension, endothelial dysfunction and increased cardiovascular risk, although its independent causal role remains debated.
- **Inflammation and metabolic dysfunction:** Chronic hyperinsulinaemia is associated with metabolic disturbances and inflammatory signalling, particularly in the presence of insulin resistance.
- **Increased cell growth and cancer risk:** Insulin activates growth-related pathways, including IGF signalling. Elevated insulin levels are associated with certain cancers, although a direct causal relationship is not established.

Acute hyperinsulinaemia Hypoglycaemia





- Insulin blocks fat burning
- Suppression of ketosis with insulin denies the type 1 body access to a vital source of fuel

- Reliance on carbohydrate blocks metabolic adaptation


Diabetes Clinic
SUPPORT • PREVENT • MANAGE • LIVE WELL
Managing Diabetes Together
Regular checks
Healthy eating
Stay active
Take medication
Prevent complications
Reception
Early Care Brighter Tomorrows
Diabetes Care For A Healthier Tomorrow
Eyes
Heart
Kidneys
Feet
Better Lives
72
98
16
Healthy Living with Diabetes
Foot Care Matters
Kidney Health
Heart Health After Diabetes
Eye Health Protect Your Vision

OKAY, so what are the numbers I need to know to make me useful for people living with T1?

CGM Summary (14 days)

Average glucose	**7.8** mmol/L
GMI (estimated HbA1c)	**6.4%** (46 mmol/mol)
Glucose variability (CV)	**32%**
Sensor wear time	**98%** (13.7 / 14 days)
Total readings	**19,728** (5-min)

Time in Ranges (3.9 – 10.0 mmol/L)

Very high	> 13.9	**5%**	(1h 40m)
High	10.1 – 13.9	**22%**	(7h 55m)
In range	3.9 – 10.0	**68%**	(23h 31m)
Low	3.0 – 3.8	**4%**	(1h 23m)
Very low	< 3.0	**1%**	(21m)

Insulin Delivery (per day)

Total daily dose (TDD)	**42.6 units**
Basal (automated + programmed)	**20.4 u (48%)**
Bolus (meal + correction)	**22.2 u (52%)**
Meal boluses	17.6 u (41%)
Correction boluses	4.6 u (11%)
Auto-corrections (AID)	2.8 u (7%)
Override / manual	0.4 u (1%)

Pump Settings (active profile)

Basal (U/hr)

Carbohydrate ratio (ICR)

06:00–11:00	**1:8 g**
11:00–17:00	**1:10 g**
17:00–22:00	**1:8 g**
22:00–06:00	**1:10 g**

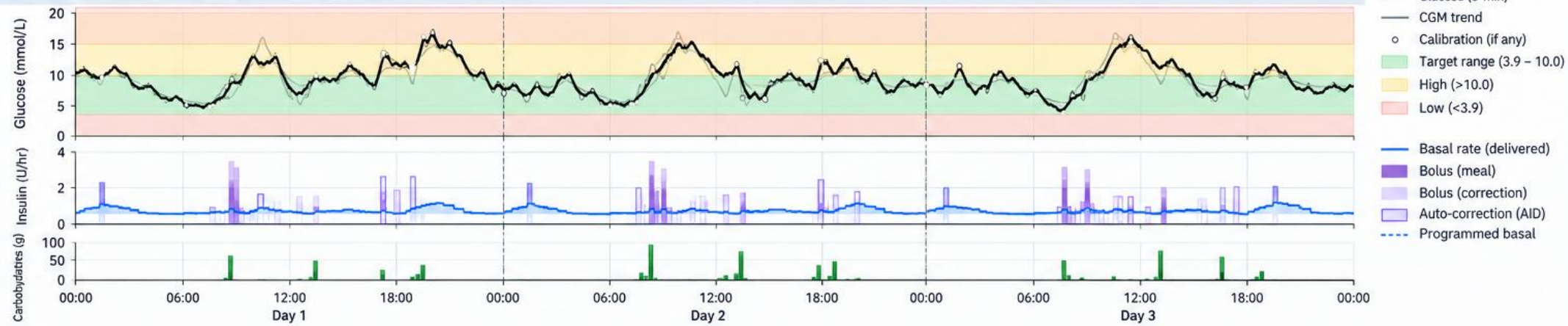
Correction factor (ISF)
1 unit : 2.8 mmol/L

Target glucose

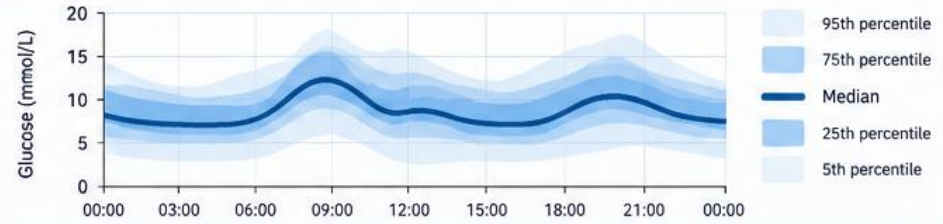
Day	6.0 mmol/L
Night	6.0 mmol/L

Active insulin time (AIT)
5 hours

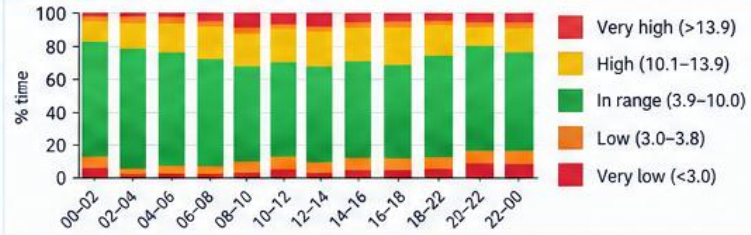
Glucose, Insulin and Carbohydrates (3 days view)



Ambulatory Glucose Profile (AGP) – 14 days



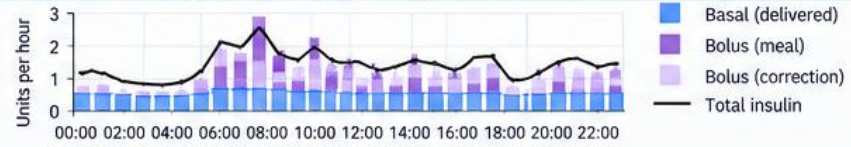
Time in Range by Time of Day



Glucose Variability

Standard deviation	2.5 mmol/L
Coefficient of variation (CV)	**32%**
Median	7.4 mmol/L
IQR (25th – 75th)	5.9 – 9.8
MAD (median absolute dev.)	1.9
MODD (day-to-day var.)	2.1
CONGA (1 h)	2.8
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MAGE	5.9
LBGI	1.2
HBGI	5.6

Insulin Delivery by Hour (average per day)



Basal Profile (24 hours)



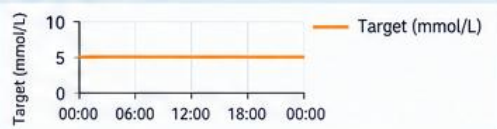
Insulin-to-Carb Ratio (ICR)



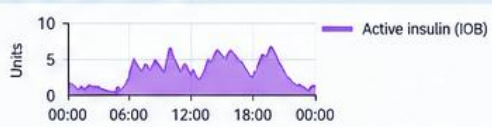
Correction Factor (ISF)



Glucose Target



Active Insulin (IOB)



Carbohydrate Intake (average per day)



Just 2!

ISF
ICR

Key Parameters for Individualising Insulin Dosing

A practical framework for bolus calculations. Varies between individuals and throughout the day slightly

INSULIN SENSITIVITY FACTOR (ISF)

Expected glucose reduction from 1 unit of rapid-acting insulin.

Correction dose ≈ (current glucose – target glucose) ÷ ISF

INSULIN–CARBOHYDRATE RATIO (ICR)

Grams of carbohydrate covered by 1 unit of insulin.

Meal bolus ≈ carbohydrate (g) ÷ ICR (g/unit)

INSULIN ON BOARD (IOB)

Active insulin remaining from previous doses. Account for IOB when considering correction boluses to reduce insulin stacking and hypoglycaemia risk.

Clinical note: Parameters vary by individual, insulin formulation, delivery system and time of day; use validated local protocols.

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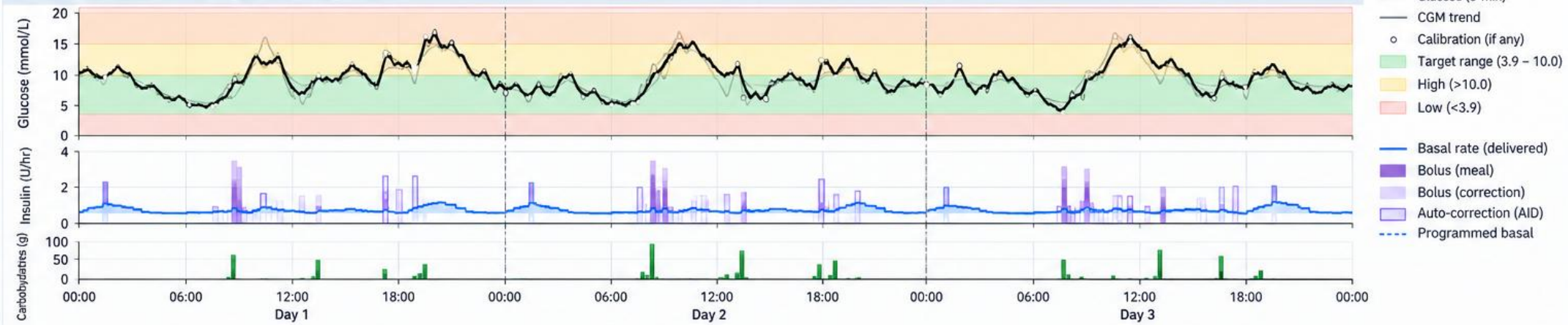
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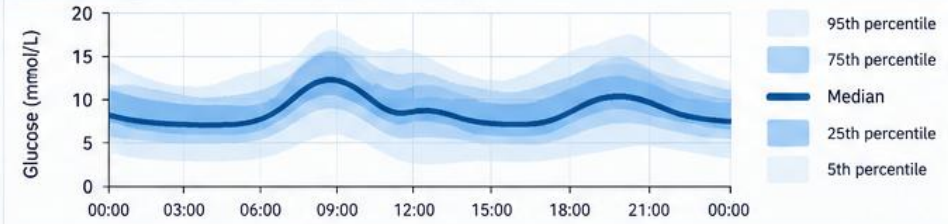
Active insulin time (AIT)

5 hours

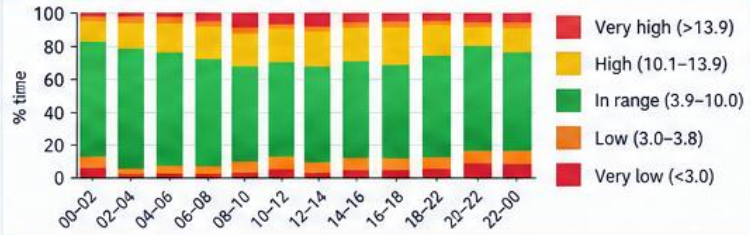
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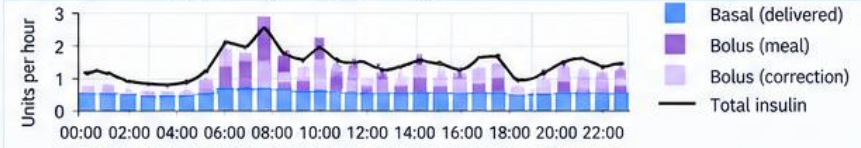
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Insulin Delivery by Hour (average per day)



Basal Profile (24 hours)



Insulin-to-Carb Ratio (ICR)



Correction Factor (ISF)



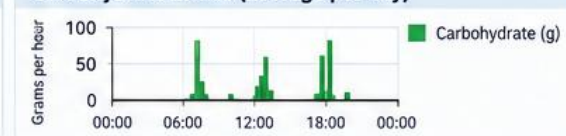
Glucose Target

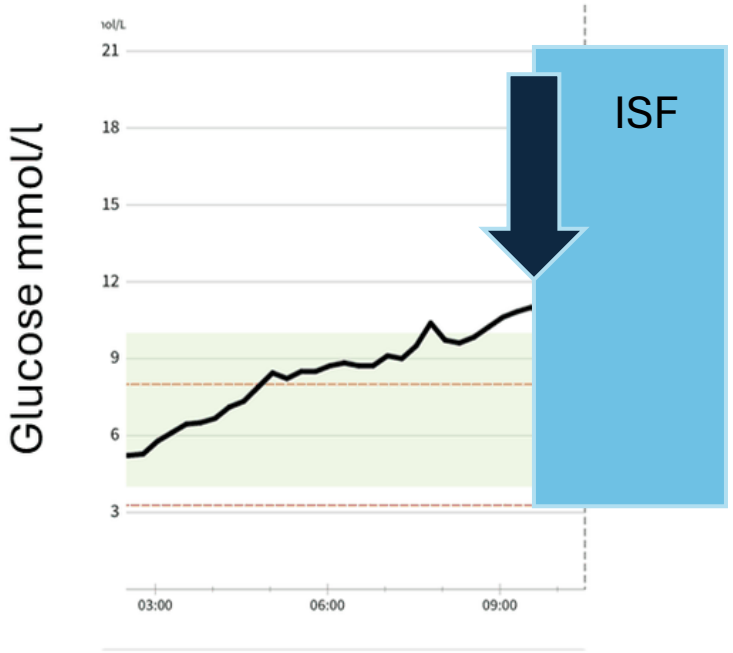


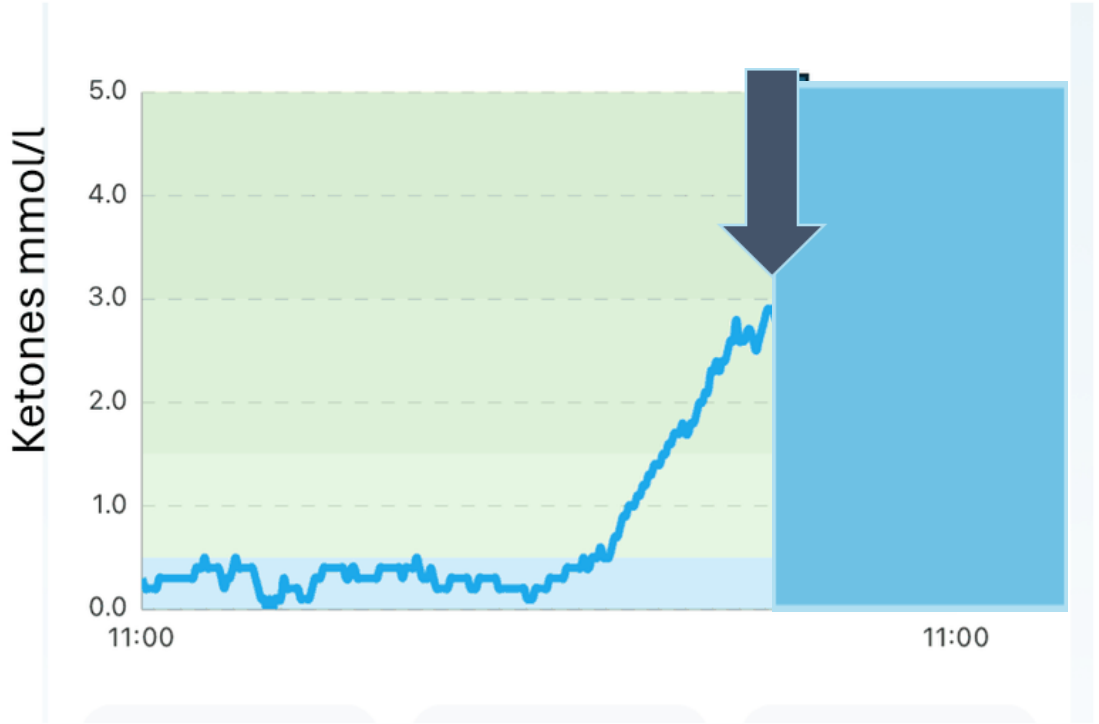
Active Insulin (IOB)



Carbohydrate Intake (average per day)




Glucose mmol/l
21
18
15
12
9
6
3
03:00
06:00
09:00
ISF


Ketones mmol/l
5.0
4.0
3.0
2.0
1.0
0.0
11:00
11:00

Basal insulin for background Bolus insulin for meals

Assessing background insulin requirements

BASAL INSULIN
Background glucose control

Structured basal assessment

Review glucose trends during clinically supervised meal-omission / fasting intervals

Glucose rises
Review for insufficient basal insulin

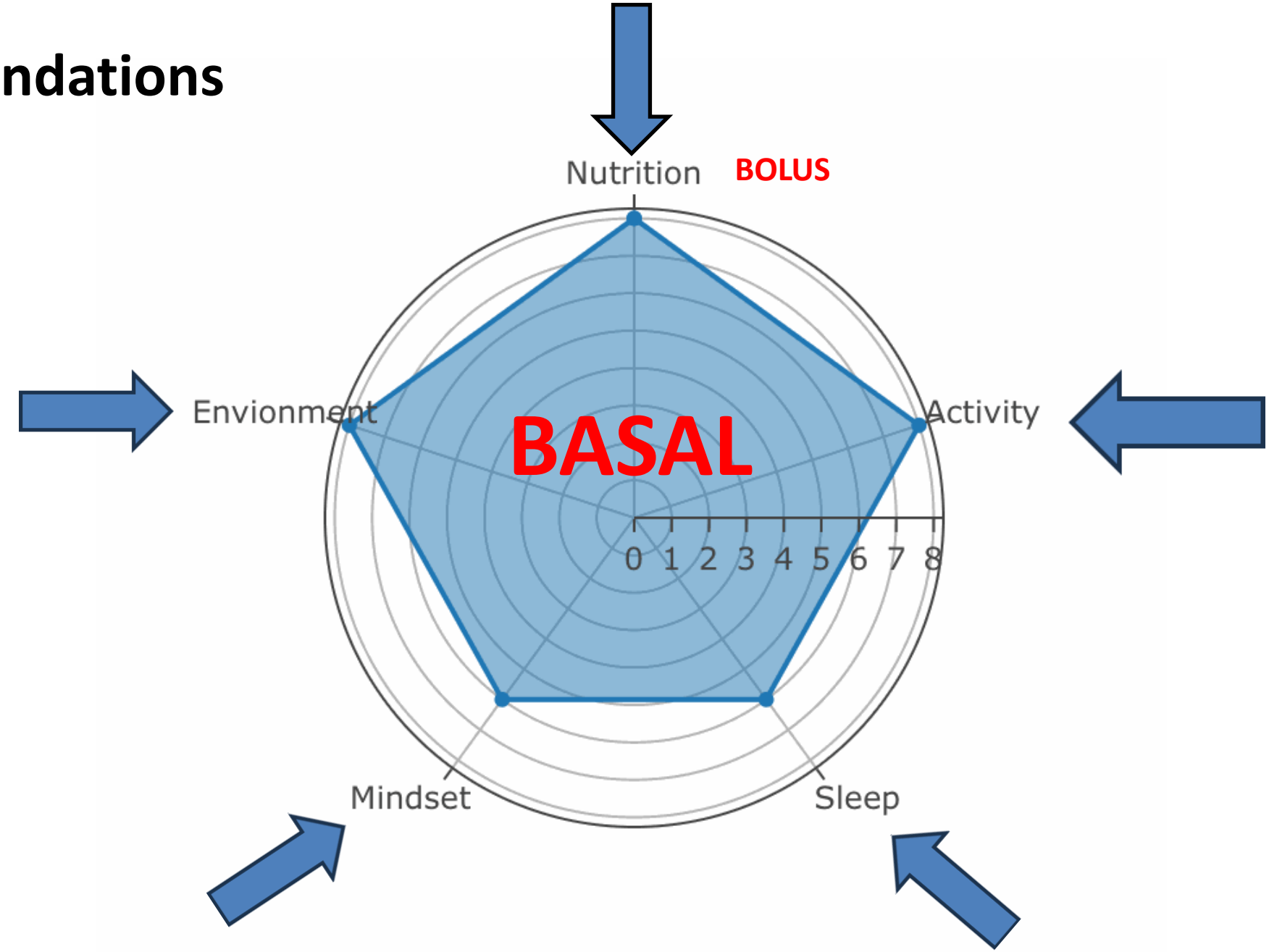
Glucose falls
Review for excessive basal insulin

Interpret alongside insulin on board, activity, illness and CGM trends; do not adjust from a single reading.

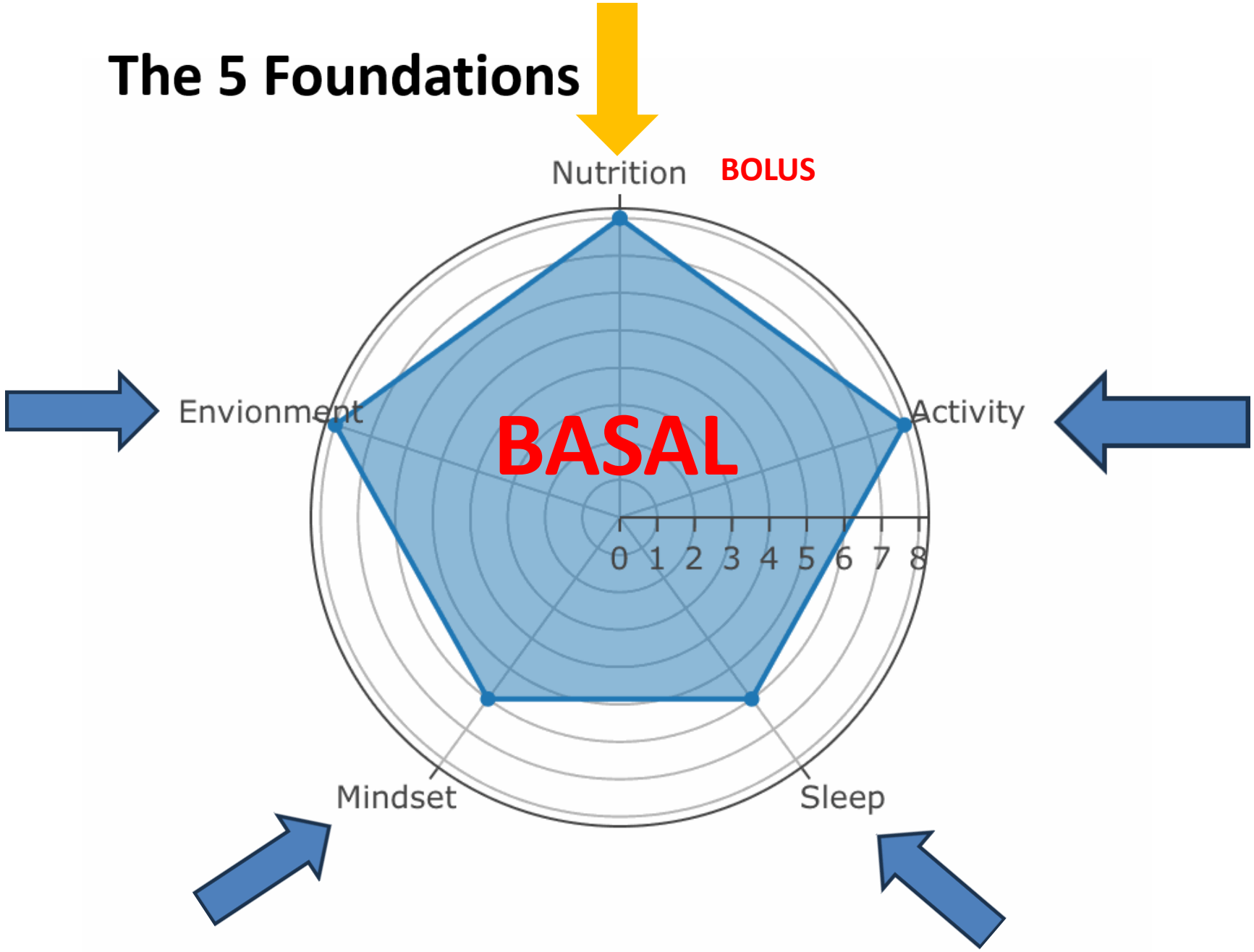
The ICR and how to transition to low carb

Steps	USUAL CARE	KETO LIFESTYLE
1	Adjust Basal Insulin	Adjust Basal Insulin
2	Count Carbohydrates	Count Carbohydrates
3	Inject Bolus Insulin to match dietary carbs	Inject Bolus Insulin to match dietary carbs
	Typically 300g carbs per day	Typically 30 g carbs per day
	30 units of rapid insulin	3 units of rapid insulin

The 5 Foundations



The 5 Foundations



Common Keto Food Groups

- Green Vegetables
- Nuts (tree nuts) /seeds
- Dairy
- Eggs
- Meat
- Fish
- Berry Fruits, Coconut
- Dark Chocolate



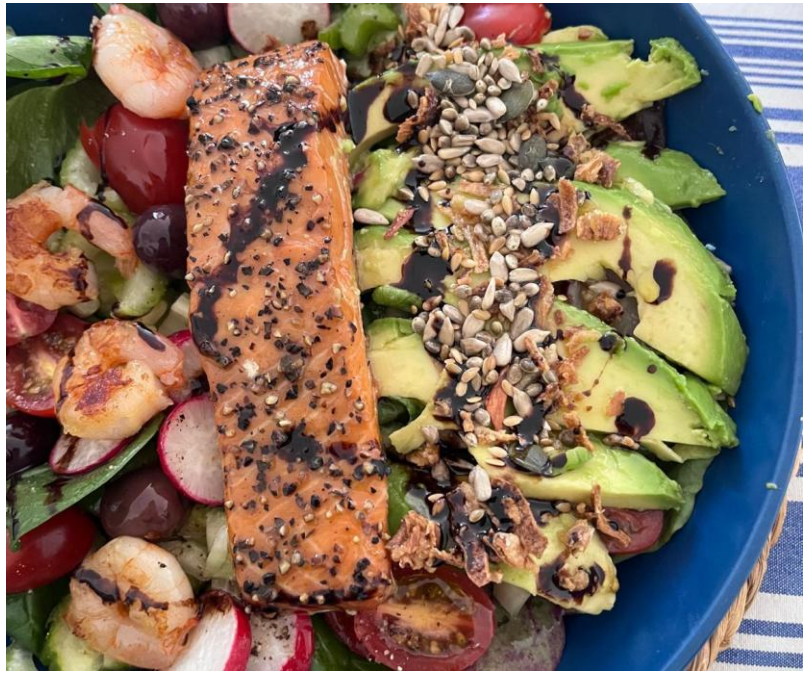







YUM

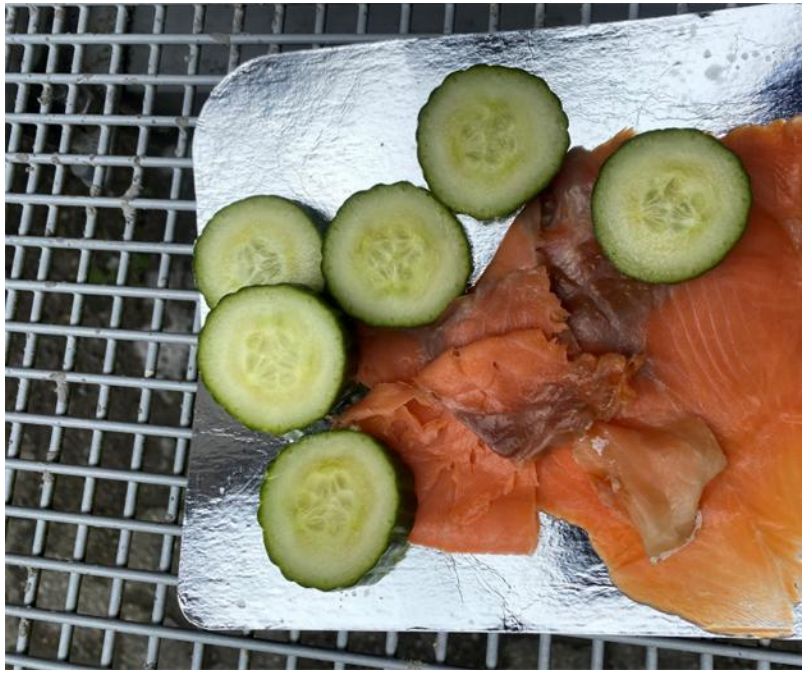




















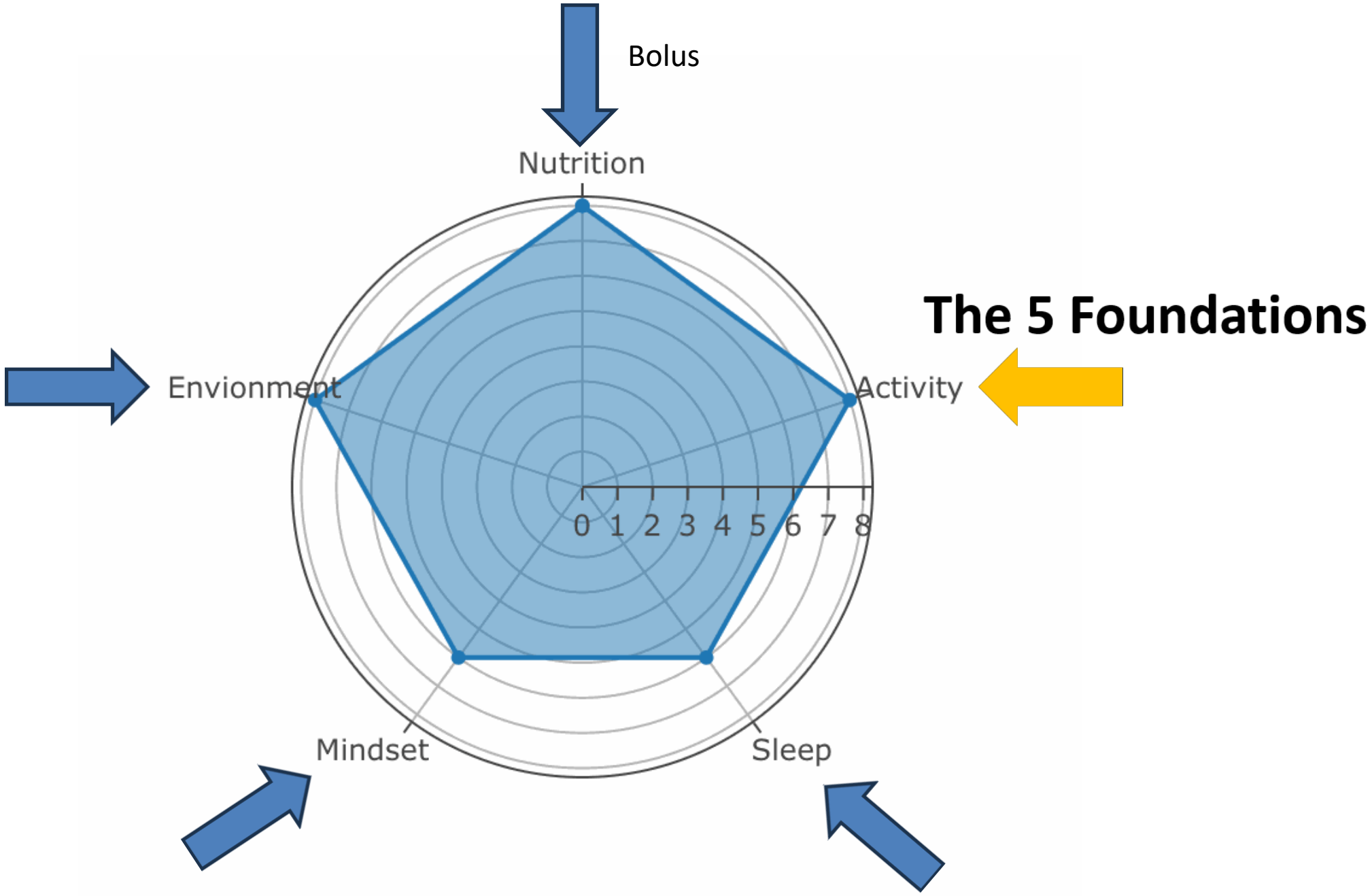


THE
low carb baking
BIBLE
BY EMMA PORTER



"KEEPING EVERYONE'S BLOOD SUGARS BALANCED
IN THE MOST DELICIOUS WAY"




Bolus
Nutrition
Envionment
Activity
Mindset
Sleep
0 1 2 3 4 5 6 7 8
The 5 Foundations

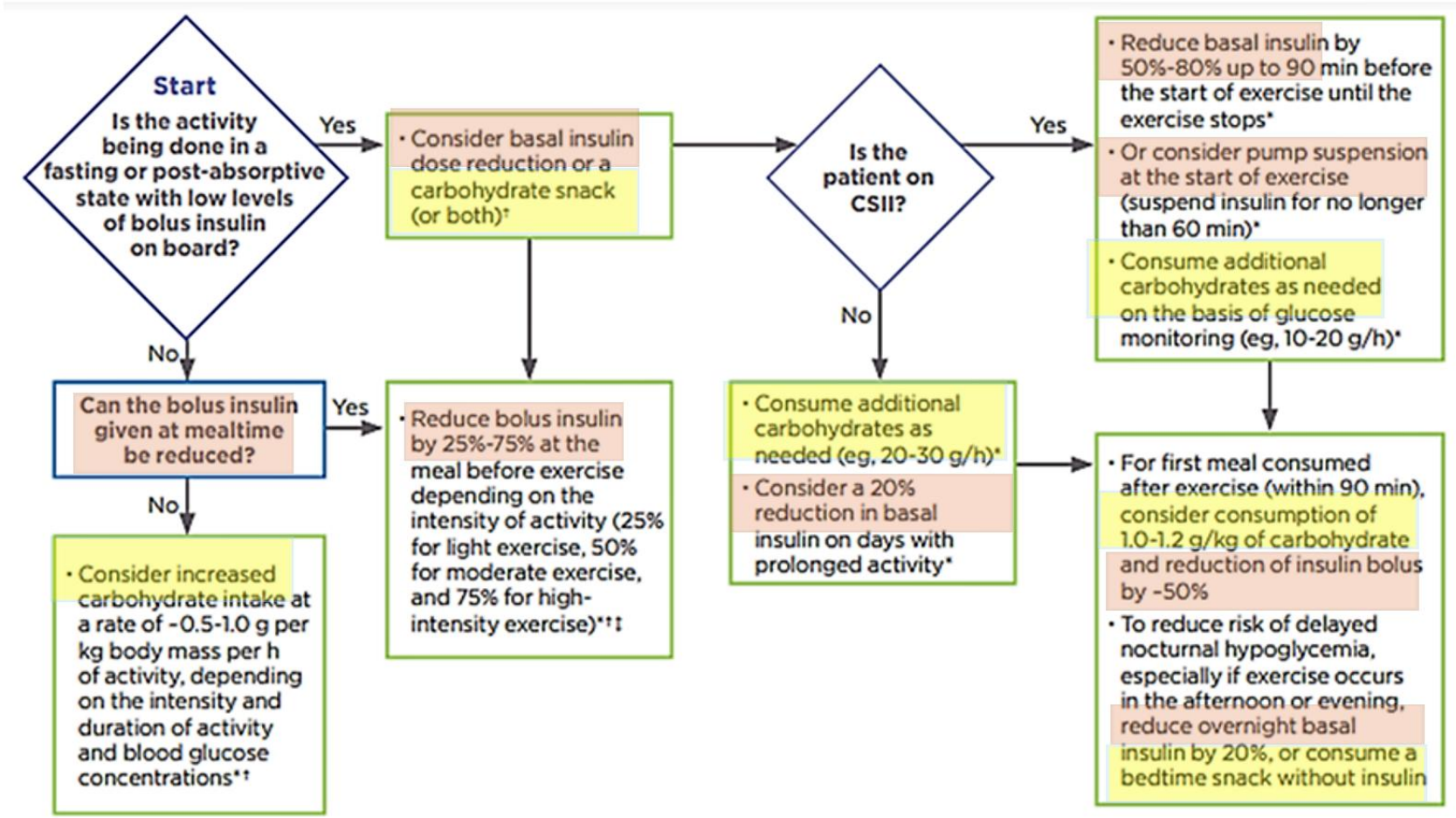
Algorithm for sugar burners

http://www.runsweet.com/diet-and-nutrition/

‘Insulin on board’

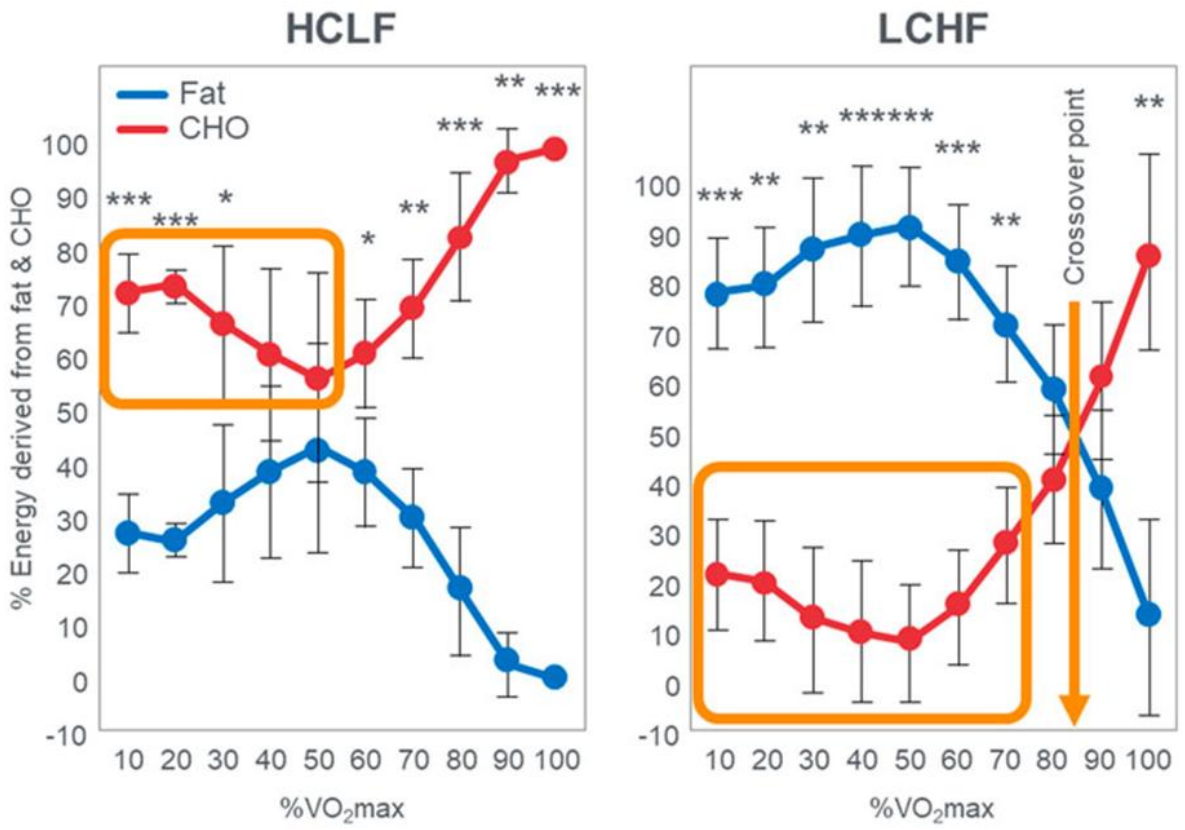
Reduction in insulin

Increase in Carbohydrate



CSII = continuous subcutaneous insulin infusion.
*Algorithm is for use in persons with T1D who are performing aerobic or mixed anaerobic/aerobic exercise lasting longer than 30 minutes. Mixed anaerobic/aerobic activities may require less reduction in insulin or lower carbohydrate intake than recommended here.
†If both resistance and aerobic exercise are to be done, resistance exercise could be done first to help attenuate hypoglycemia.
‡In some situations, such as Nordic skiing, marathon running, or prolonged cycling and trekking, increased carbohydrate feeding rather than insulin dose reduction might help improve endurance performance in prolonged activities. In other situations, both bolus and basal insulin dose reductions might be needed to help restrict or reduce carbohydrate intake. Continuous glucose monitoring could be considered where patient or parent preference dictates, or in individuals with a history of nocturnal or severe hypoglycemia.
Reprinted with permission from Riddell MC, Gallen IW, Smart CE, et al. Exercise management in type 1 diabetes: a consensus statement. *Lancet Diabetes Endocrinol.* 2017;5(5):377-390.

Crossover Point



https://doi.org/10.3389/fphys.2023.1150265

Exercise and insulin: simplified decision pathway: Optimised Insulin

Insulin on board?
Active insulin remaining

No excess

Is exercise planned?

NO

Eat or fast as you wish

YES

Fasted exercise
Monitor glucose; adjust carbohydrate and insulin as needed

Post-exercise
Continue usual routine

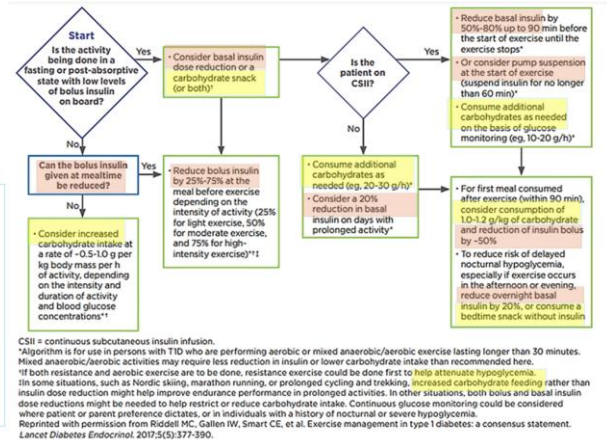
Algorithm for sugar burners

'Insulin on board'

Reduction in insulin

Increase in Carbohydrate

http://www.runsweet.com/diet-and-nutrition/



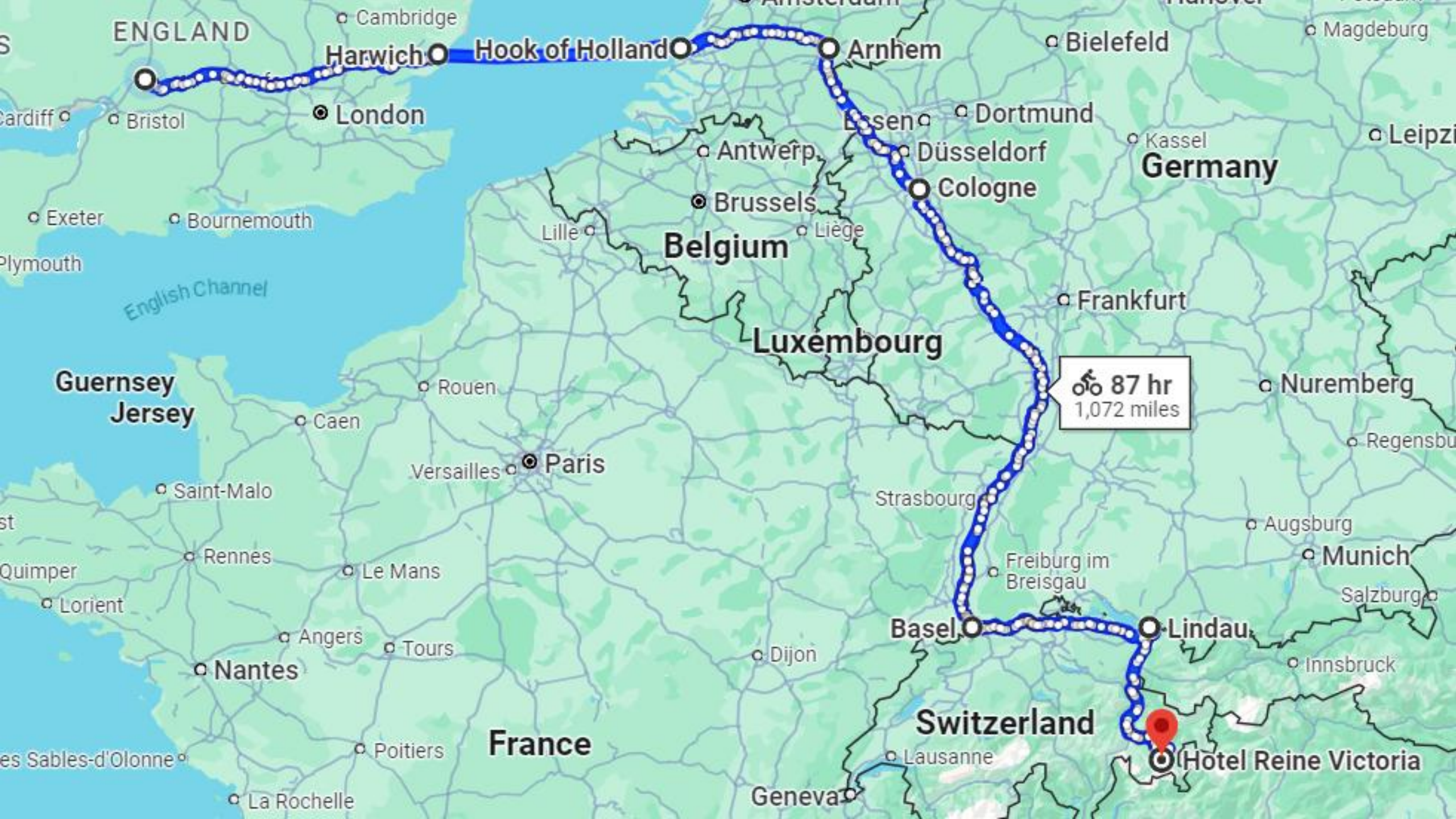
Clinical note: Individualise according to glucose trends, insulin action, exercise intensity and hypoglycaemia risk.

ZERO FIVE 100

ZERO CALORIES DAYS 100 MILES

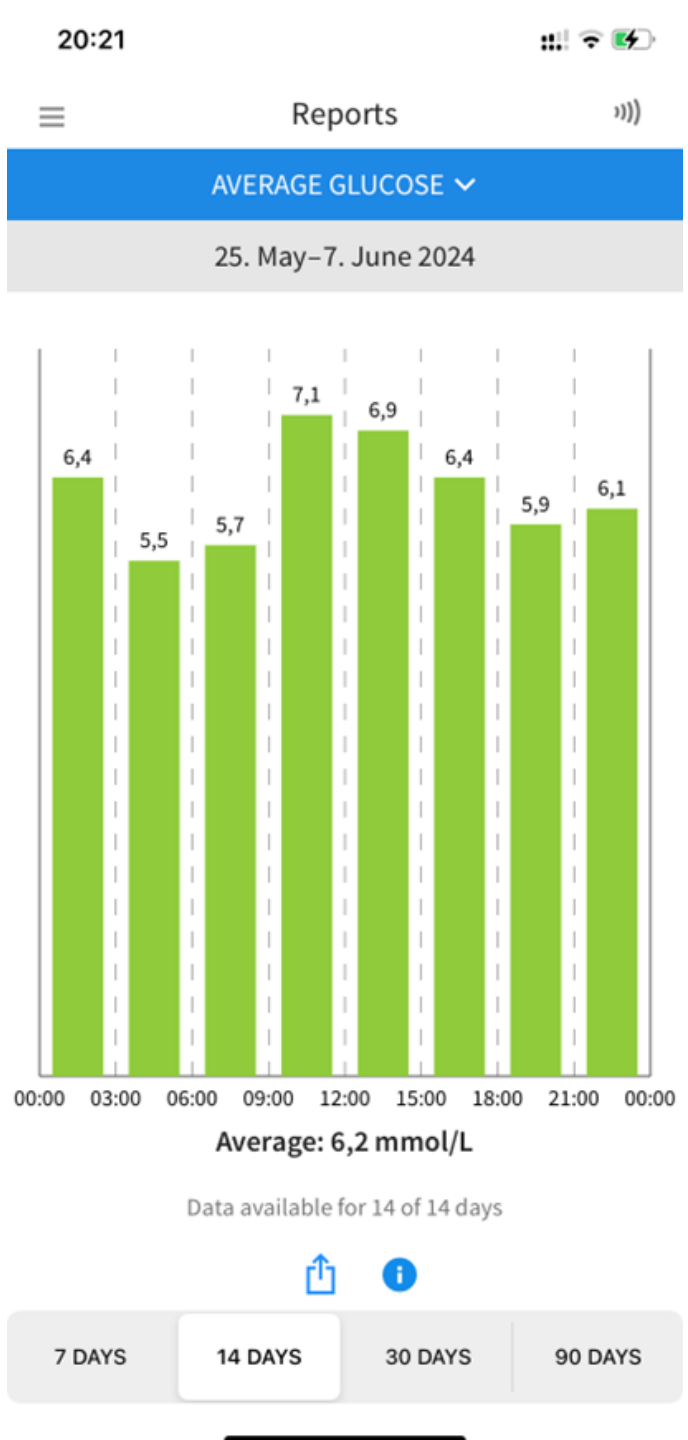


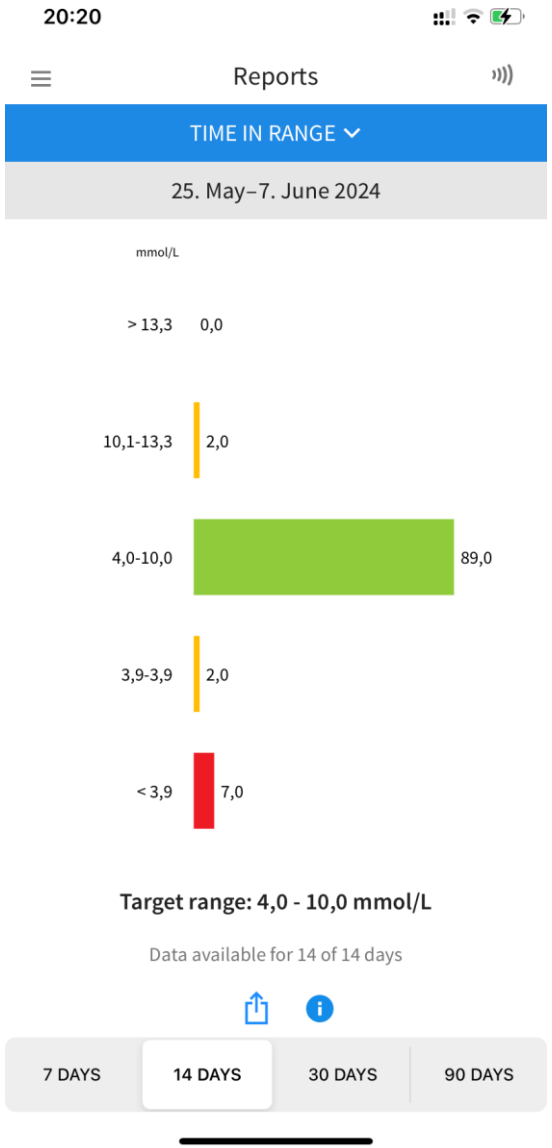
www.zerofive100.com zero calories, five days, 100 miles

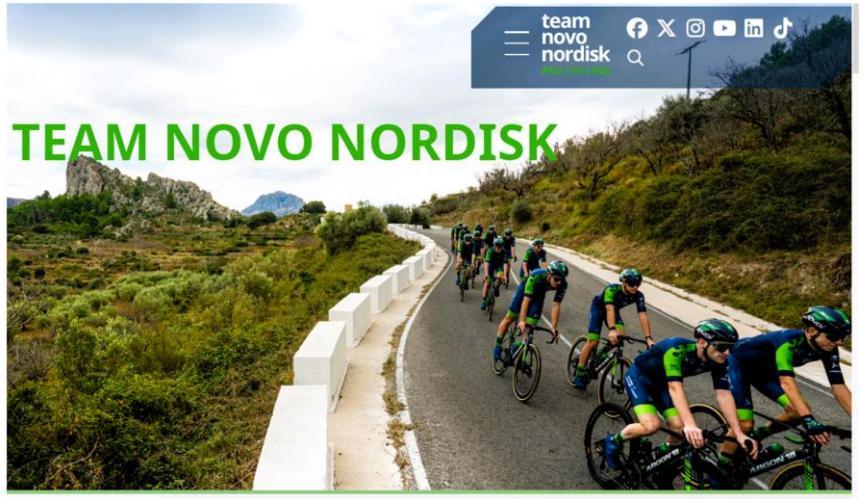

ENGLAND
Cambridge
Harwich
Hook of Holland
Arnhem
Bielefeld
Magdeburg
London
Cardiff
Bristol
Dortmund
Kassel
Antwerp
Düsseldorf
Germany
Cologne
Brussels
Exeter
Bournemouth
Lille
Liège
Belgium
Plymouth
English Channel
Frankfurt
Luxembourg
87 hr
1,072 miles
Guernsey
Jersey
Rouen
Nuremberg
Caen
Versailles
Paris
Regensbu
Saint-Malo
Strasbourg
Augsburg
Rennes
Freiburg im
Breisgau
Munich
Quimper
Le Mans
Salzburg
Lorient
Basel
Lindau
Angers
Tours
Dijon
Innsbruck
Nantes
Switzerland
Poitiers
France
Lausanne
Hotel Reine Victoria
Geneva
La Rochelle

Insulin dose reduced

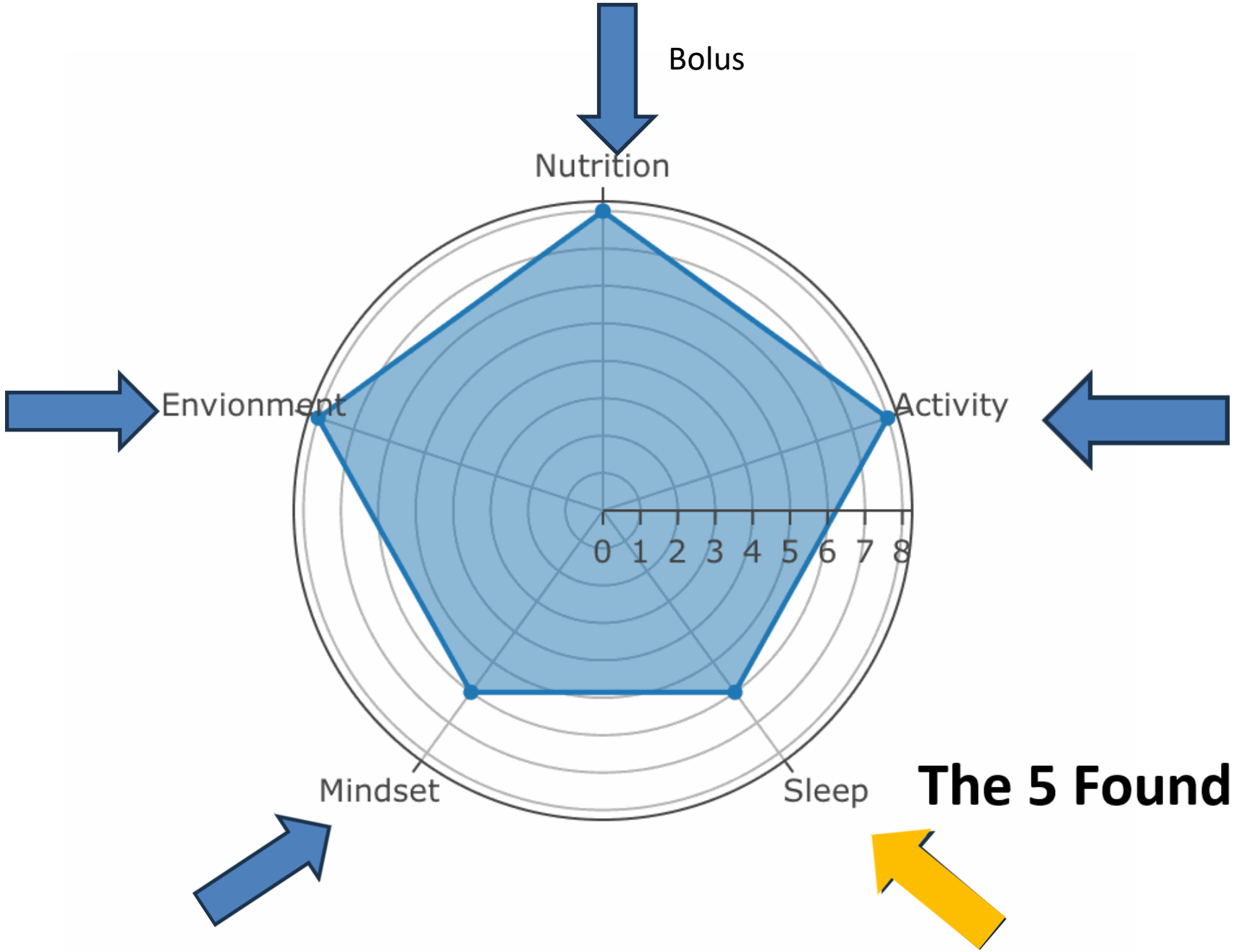
compared to the normal daily dose.







The time spent in euglycemia (76%) was categorized as ‘very good’ against current clinical recommendations[19] and commendable for a team of cyclists riding on average 4.3 hours and consuming ~5000 kcal each day.



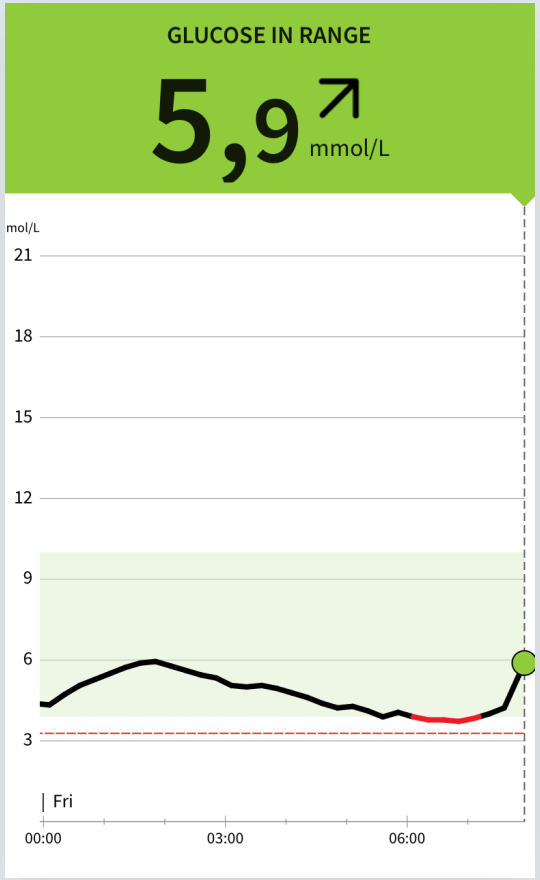
The 5 Foundations

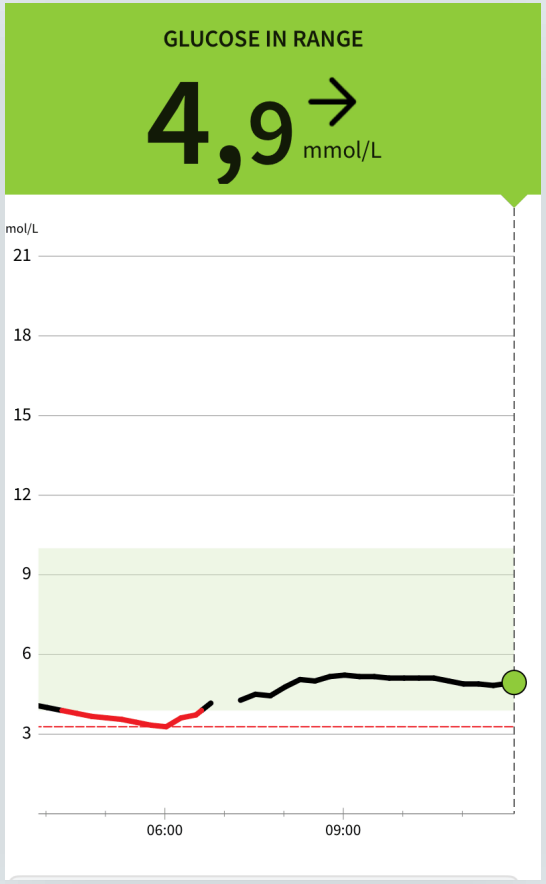
Circadian Rhythms

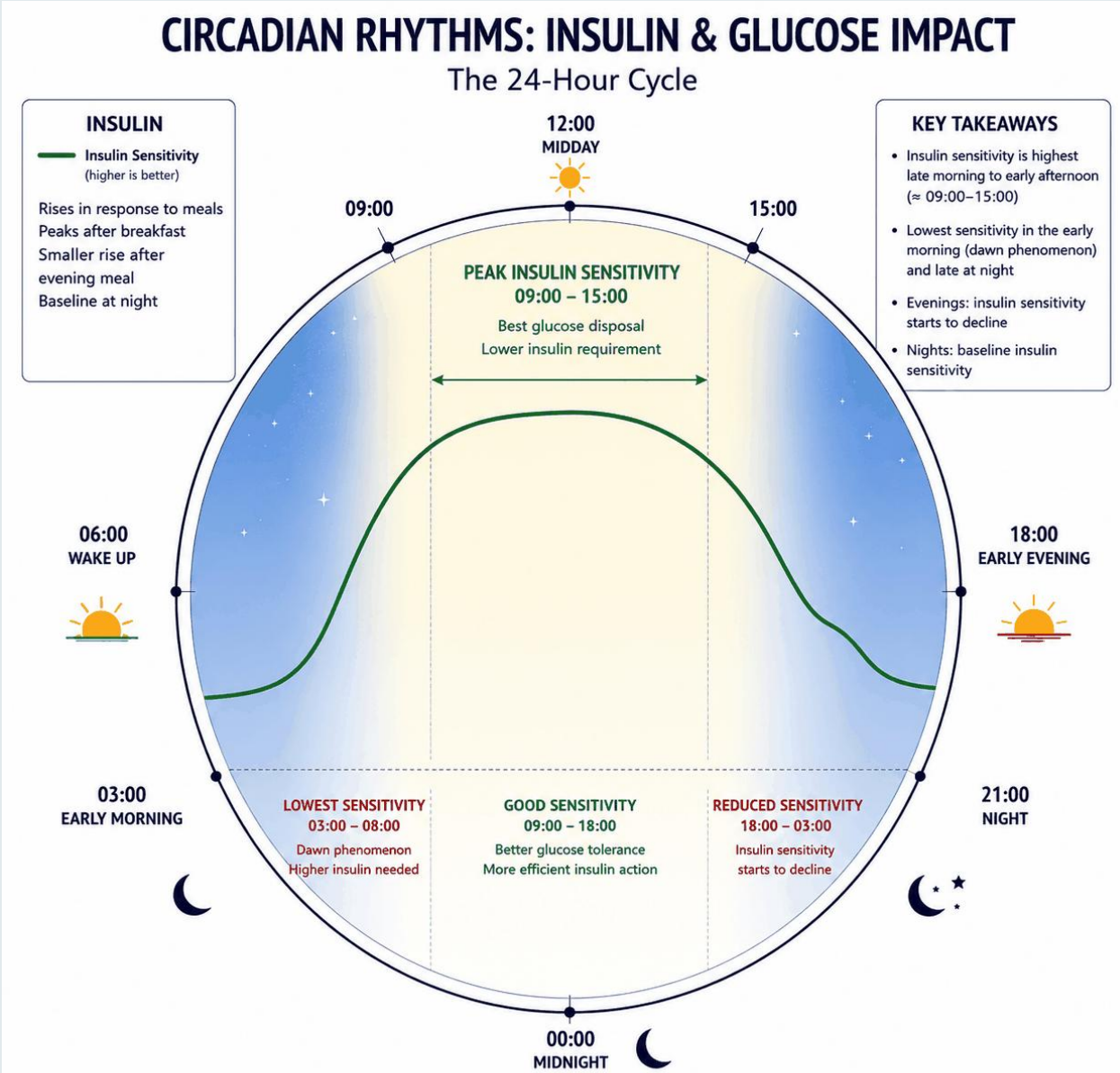




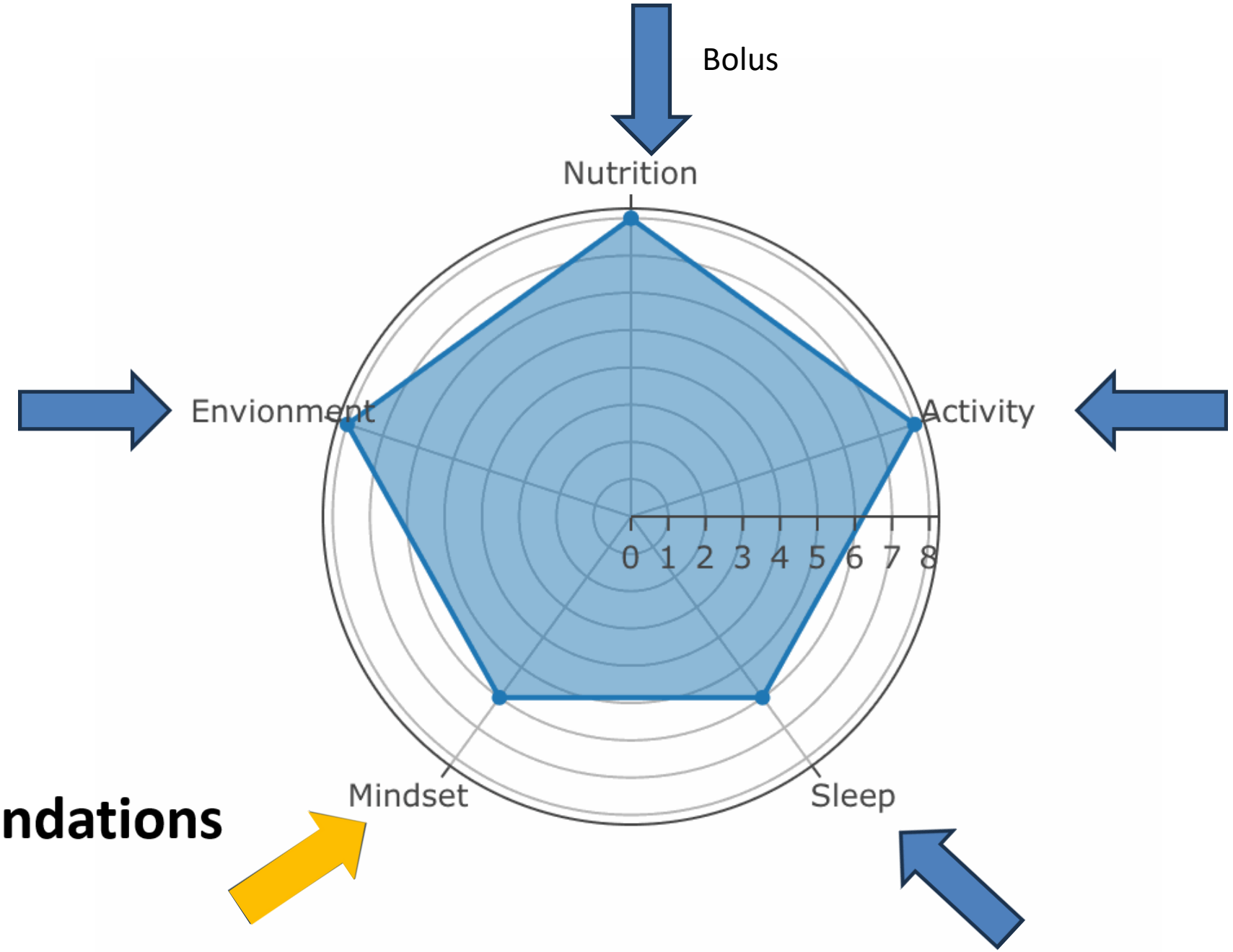
Dawn Effect

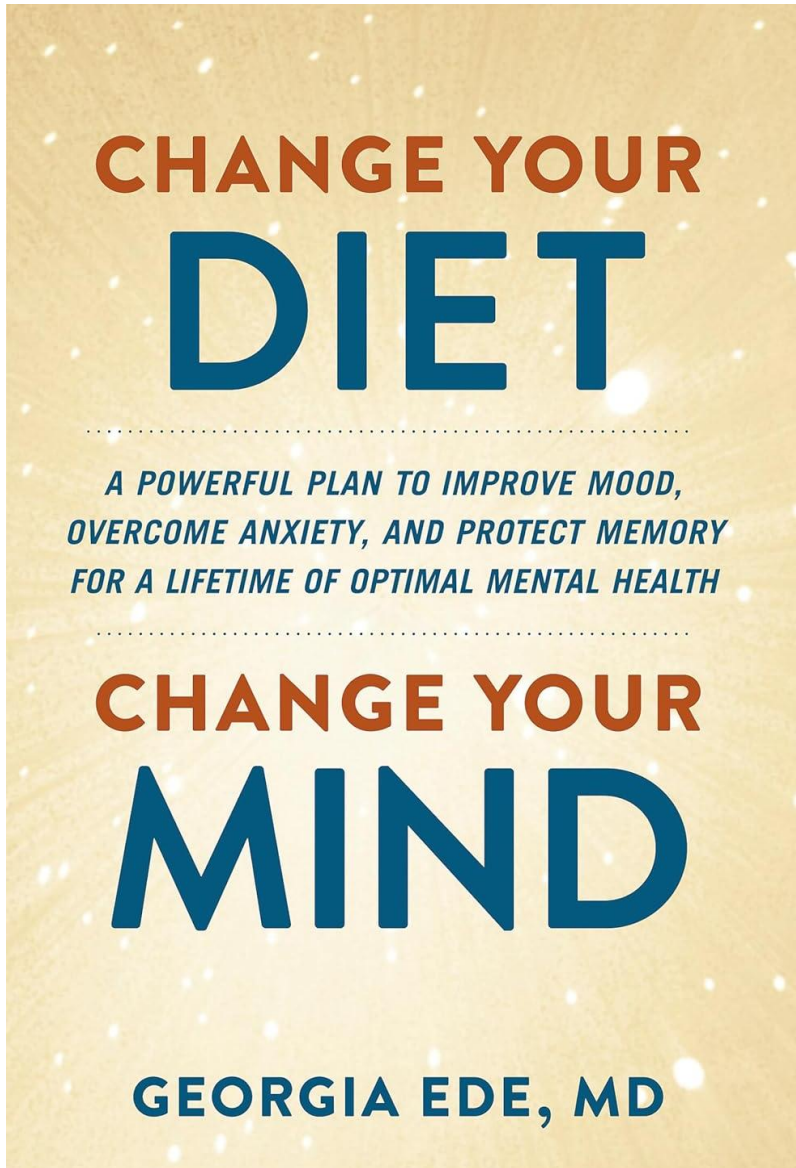

GLUCOSE IN RANGE
5,9 ↗ mmol/L
mol/L
21
18
15
12
9
6
3
Fri
00:00
03:00
06:00

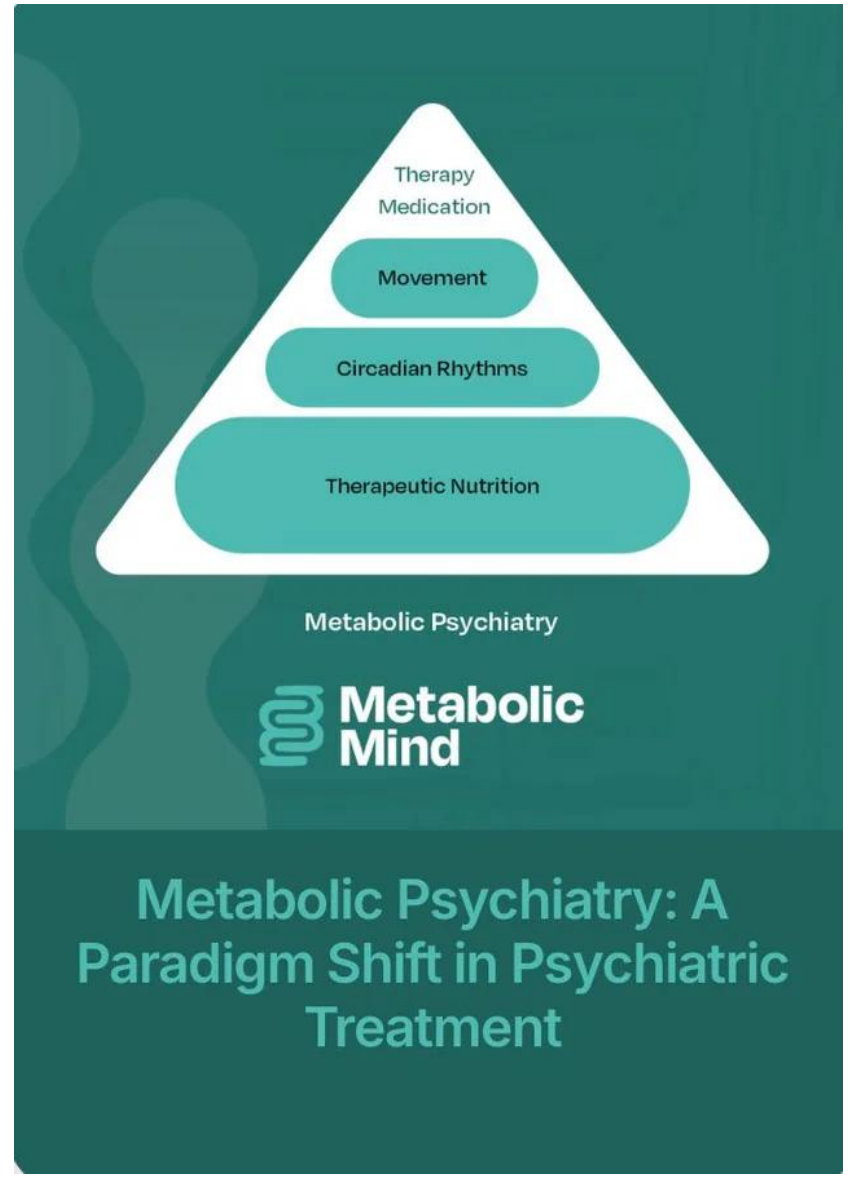

GLUCOSE IN RANGE
4,9 → mmol/L
mol/L
21
18
15
12
9
6
3
06:00
09:00


CIRCADIAN RHYTHMS: INSULIN & GLUCOSE IMPACT
The 24-Hour Cycle
INSULIN
Insulin Sensitivity
(higher is better)
Rises in response to meals
Peaks after breakfast
Smaller rise after evening meal
Baseline at night
12:00
MIDDAY
09:00
15:00
PEAK INSULIN SENSITIVITY
09:00 – 15:00
Best glucose disposal
Lower insulin requirement
KEY TAKEAWAYS
Insulin sensitivity is highest late morning to early afternoon (≈ 09:00–15:00)
Lowest sensitivity in the early morning (dawn phenomenon) and late at night
Evenings: insulin sensitivity starts to decline
Nights: baseline insulin sensitivity
06:00
WAKE UP
18:00
EARLY EVENING
03:00
EARLY MORNING
21:00
NIGHT
LOWEST SENSITIVITY
03:00 – 08:00
Dawn phenomenon
Higher insulin needed
GOOD SENSITIVITY
09:00 – 18:00
Better glucose tolerance
More efficient insulin action
REDUCED SENSITIVITY
18:00 – 03:00
Insulin sensitivity starts to decline
00:00
MIDNIGHT

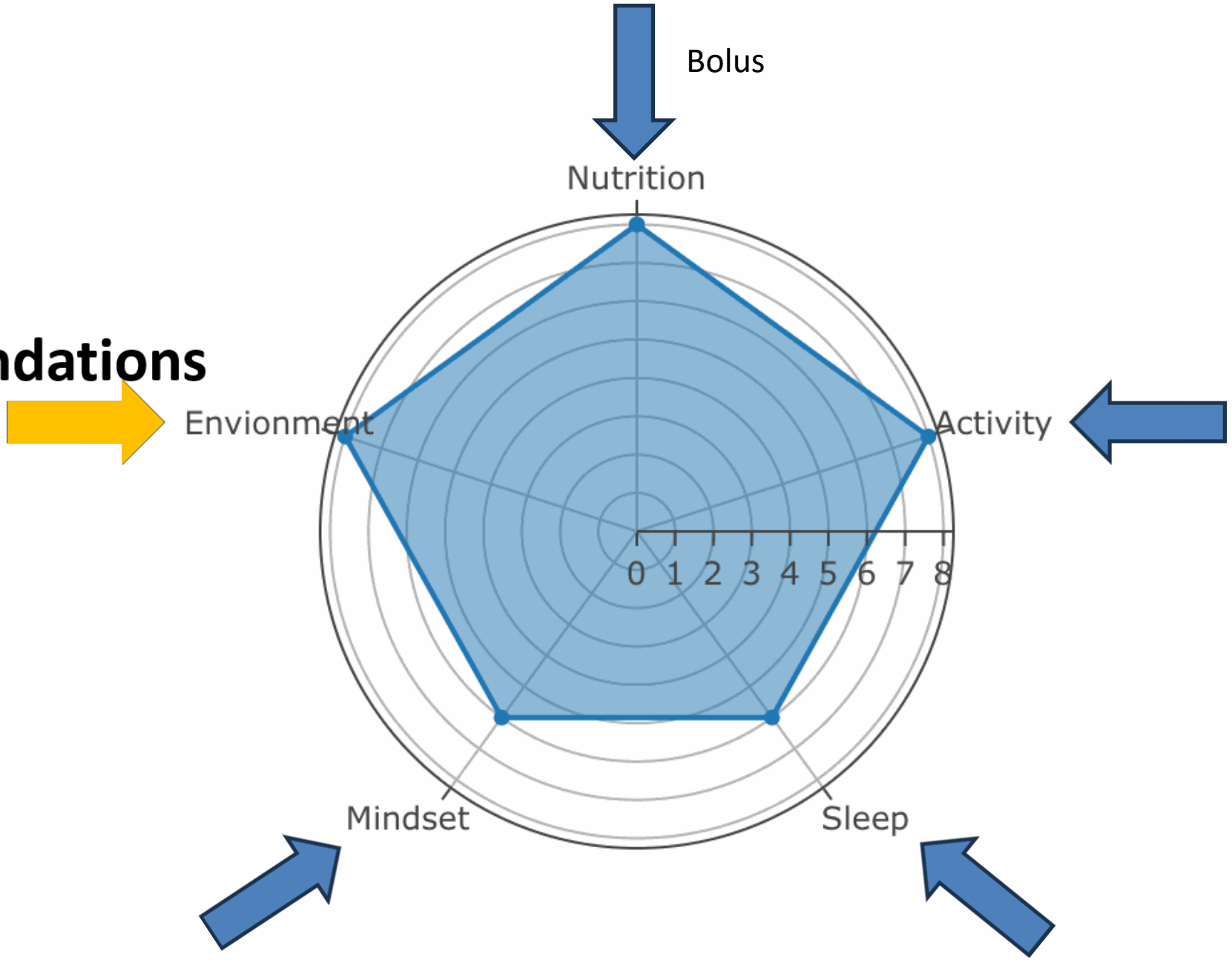
The 5 Foundations




CHANGE YOUR
DIET
A POWERFUL PLAN TO IMPROVE MOOD, OVERCOME ANXIETY, AND PROTECT MEMORY FOR A LIFETIME OF OPTIMAL MENTAL HEALTH
CHANGE YOUR
MIND
GEORGIA EDE, MD


Therapy
Medication
Movement
Circadian Rhythms
Therapeutic Nutrition
Metabolic Psychiatry
Metabolic Mind
Metabolic Psychiatry: A Paradigm Shift in Psychiatric Treatment

The 5 Foundations

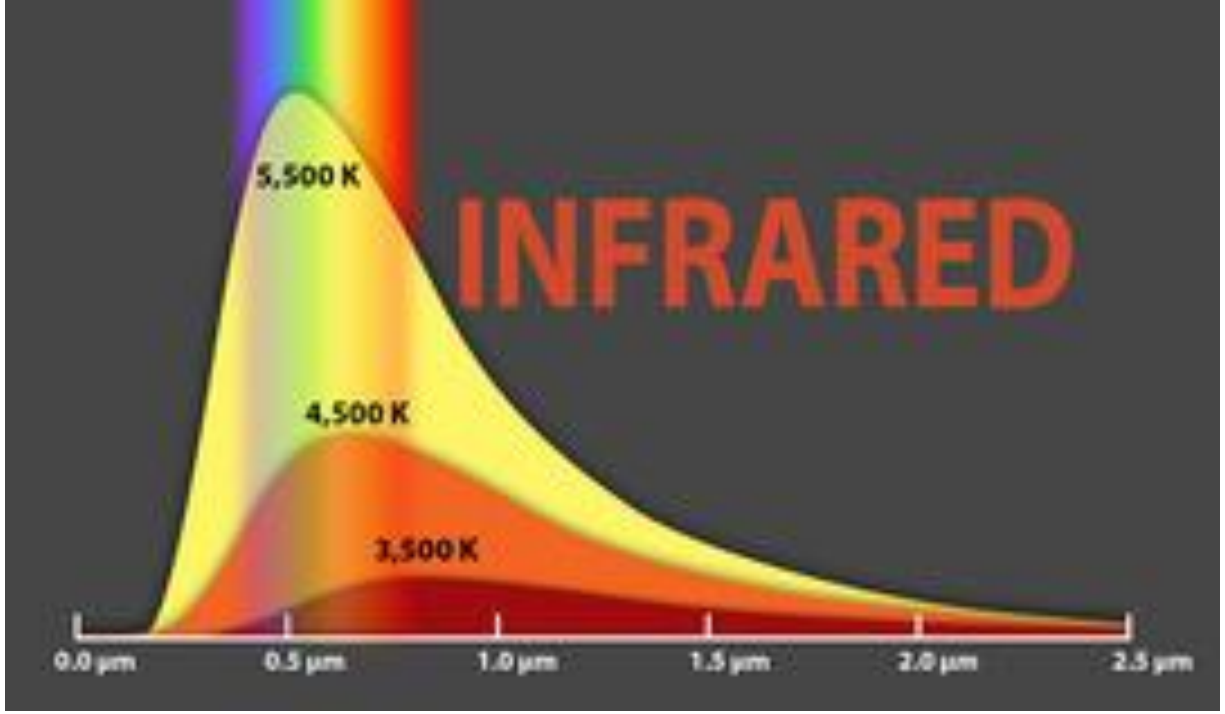




Ulrich (1984): Effect of a nature view on recovery after surgery

Reference: Ulrich RS. View through a window may influence recovery from surgery. Science. 1984;224(4647):420–421. DOI: 10.1126/science.6143402.

Outcome	Tree view (n=23)	Brick wall view (n=23)	Difference	
Hospital stay	7.96 days	8.70 days	0.74 days shorter	**9%**
Moderate and strong painkillers	Fewer doses	More doses	Significantly lower	
Negative nursing observations	Fewer	More	Significantly fewer	



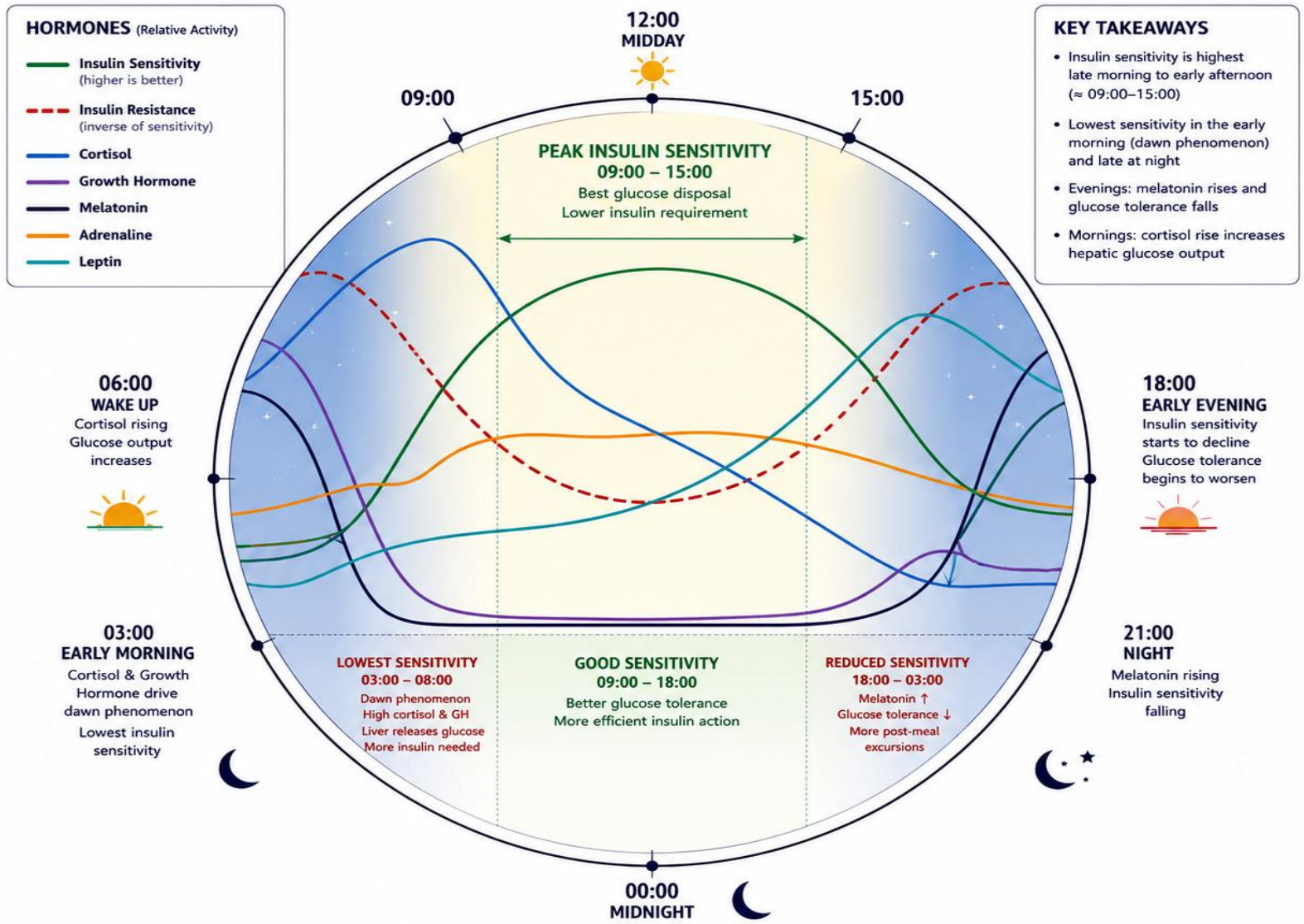
.

Mitochondrial melatonin: Acts as an intracellular antioxidant, potentially protecting mitochondria against oxidative damage.

Morning daylight and reduced artificial light at night support melatonin rhythms, sleep quality and more predictable insulin action.

CIRCADIAN RHYTHMS, INSULIN SENSITIVITY & GLUCOSE IMPACT

The 24-Hour Cycle



KEY TAKEAWAYS

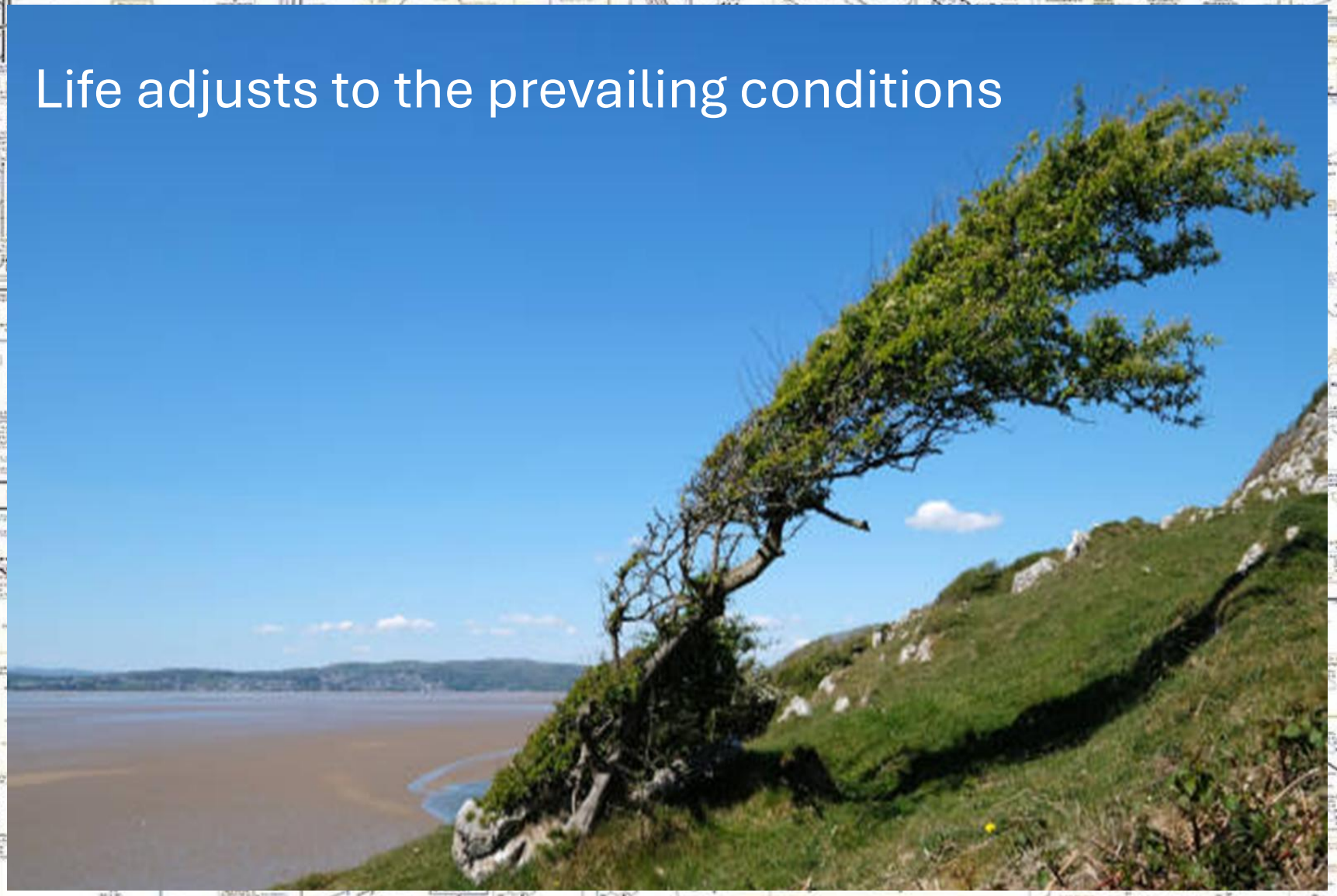
- Insulin sensitivity is highest late morning to early afternoon (≈ 09:00–15:00)
- Lowest sensitivity in the early morning (dawn phenomenon) and late at night
- Evenings: melatonin rises and glucose tolerance falls
- Mornings: cortisol rise increases hepatic glucose output

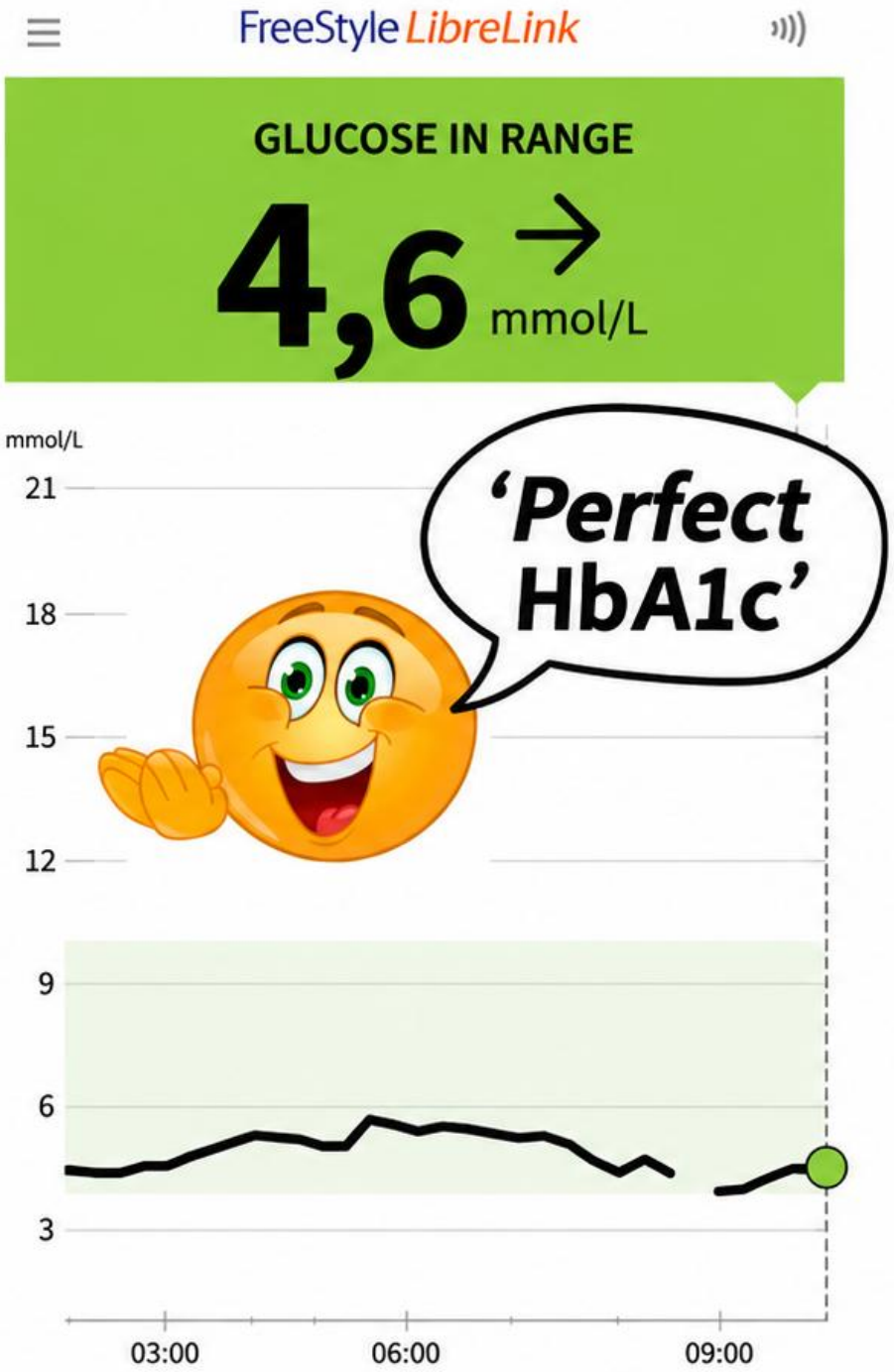
GLUCOSE IMPACT	03:00 – 08:00	09:00 – 15:00	15:00 – 18:00	18:00 – 03:00
	Higher fasting glucose likely More insulin needed Dawn phenomenon	Best glucose control window Lower insulin needed Better post-meal response	Stable period Good glucose control	Higher post-meal glucose More variable glucose More insulin needed

Individual responses vary. This is a general pattern in most people.

Healthy

Life adjusts to the prevailing conditions





Does it matter how much insulin we use to get a normal glucose trace?



No metabolic illness



11 years

Wrong fuel



metabolic illness
120U insulin per day





15 months

Right fuel

Metabolic Illness
25U insulin per day



Wrong fuel



metabolic illness
120U insulin per day



YOU CAN'T POLISH IT.
BUT YOU CAN MAKE IT SPARKLE.

Technology is remarkable.
The question is what we ask it to solve.



Diabetes technology has transformed what is possible for people with type 1 diabetes. I use it. I value it.

But increasingly sophisticated technology also raises a question.

Are we sometimes using technology to manage a metabolic problem that might also be addressed further upstream?

A CGM can measure glucose extraordinarily well. A pump can deliver insulin with extraordinary precision. Neither, by itself, asks why that amount of insulin was required in the first place.

This is where nutrition becomes interesting.

Low-carbohydrate nutrition in type 1 diabetes deserves serious scientific consideration. Not because technology is bad, and certainly not because insulin is optional — it isn't — but because reducing unnecessary metabolic demand may change the job we are asking both insulin and technology to do.

Perhaps the question isn't technology or nutrition.

Perhaps it's whether excellent technology is being applied to the best possible metabolic environment.

SHIFT

KEEP WHAT IS WORKING.
QUESTION WHAT IS NOT.

- **Bolus calculations are essential. But they are not the whole story.**

- **If we understand the five foundations of health, perhaps we can begin to optimise the person, rather than simply adjusting the insulin.**

- **Insulin requirements are dynamic, and they reflect much more than the carbohydrate on a plate.**

INSULIN is a MODIFIABLE VARIABLE in EVERYONE.

And it ideally should be low.

High-carb conventional diet; 40 Units a day.

Ketogenic diet. 24U /day.

Ketogenic diet with prolonged exercise (60 miles a day for 3 weeks) : 16 U /day

Five day fast running 20 miles a day(Zerofive100 project); 4 U / day.

Covid-19 and keto diet. 56 U /day.

Yet only T1 are aware of it.

Insulin: As much as needed, as little as possible

For everyone!

Thank you!

www.type1keto.com

