Continuous Glucose Monitoring of Non-Diabetic Professional Cyclists during a Training Camp

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POWER BANDS	TIME IN ZONE (h:min:ss)	TIME IN ZONE (%)
0-1.9 W/kg	1:23:11	22,5
2.0-4.9 W/kg	4:06:08	66,5
5-7.9 W/kg	0:36:43	9,9
>8 W/kg	0:04:14	1,1

About 10-15% of the race time is spent in glycolitic zone

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CARBOHYDRATES INTAKES IN ENDURANCE EVENTS

Duration of exercise	Amount of carbohydrates needed	Recommended type of carbohydrates
45 to 75 min	**0–20 g/hr** Mouth rinse or small CHO* amount	**Single or multiple transportable CHO** e.g. glucose or glucose + fructose
1–2.5 hr	**30–60 g/hr** CHO drinks or gels/ confectionery	**Single or multiple transportable CHO** e.g. glucose or glucose + fructose
>2.5 hr	**Up to 90 g/hr** Mix of CHO drinks & more concentrated gels/ confectionery	**ONLY multiple transportable CHO** e.g. glucose + fructose or glucose polymers like maltodextrin

Reference: Burke et al. IJSNEM 2019

Designed by @YLMSportScience

*CHO: carbohydrates

Images provided by PresenterMedia

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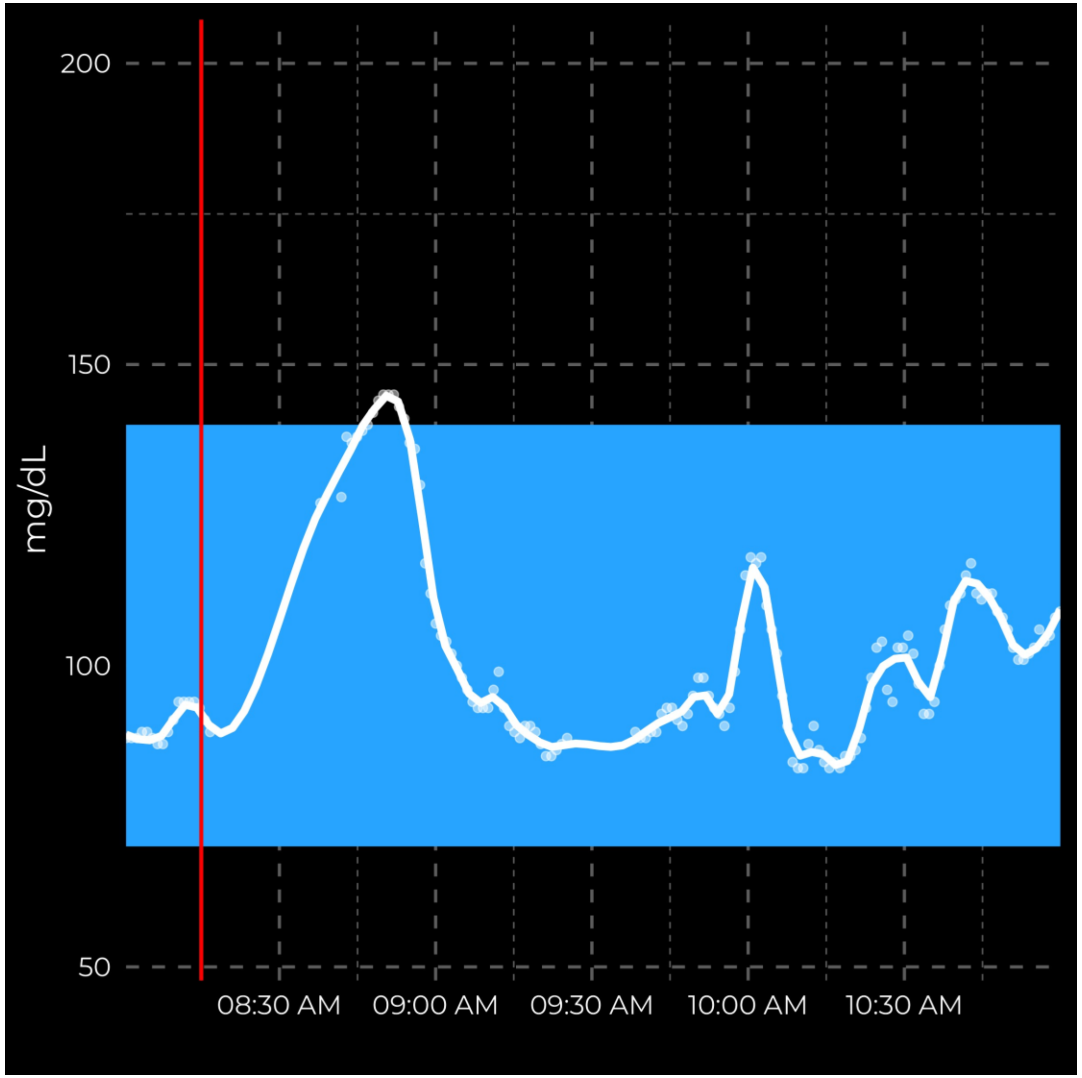
LOW CARBOHYDRATE AVAILABILITY

Insufficient glycogen concentration and inadequate blood glucose supply in comparison with the fuel needs of an exercise session.

PERFORMANCE IMPAIRMENT

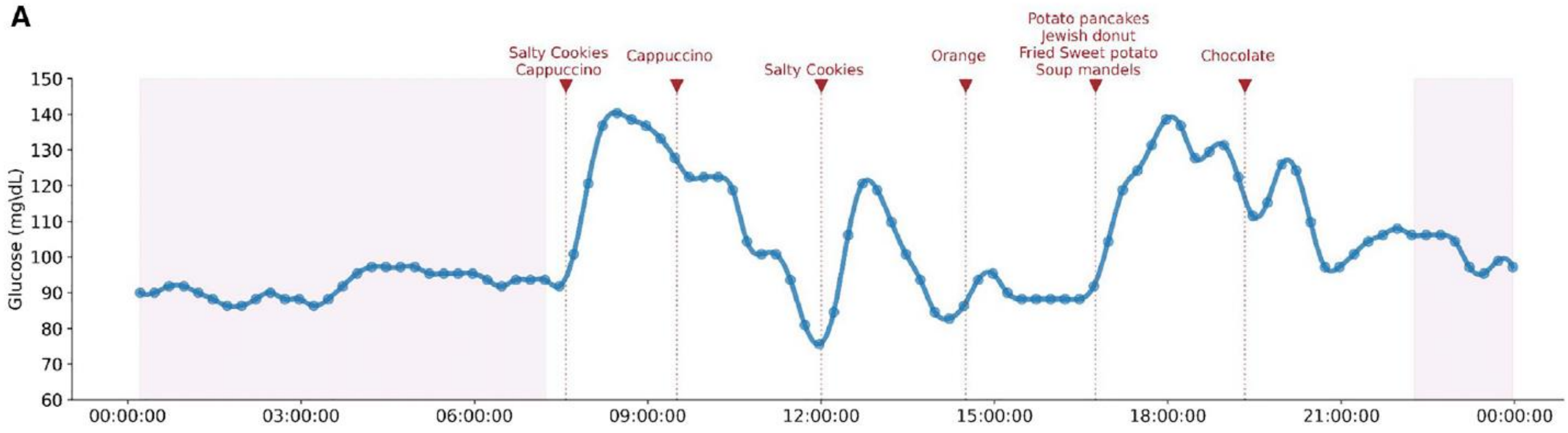
How feeding influences glycemia

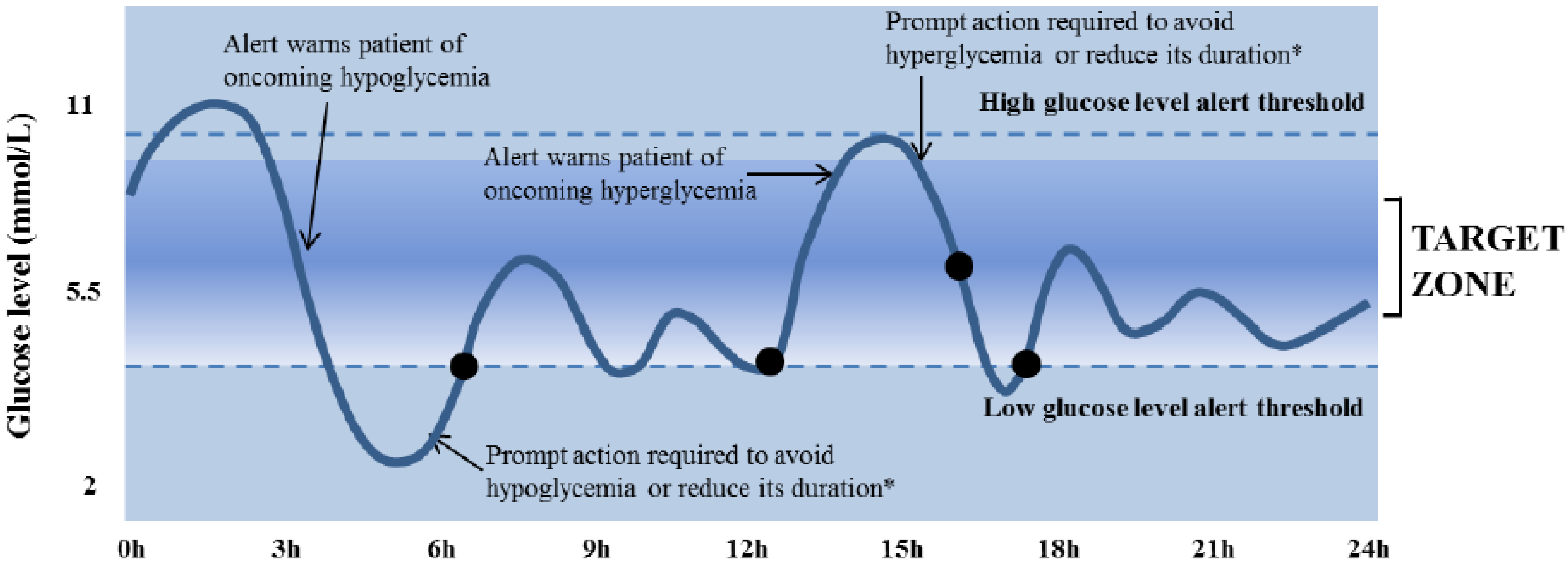


The Glycemia Peak is reached around 1 – 2 hours after the meal (max 160mg/dl).

Glycemia comes back to normal values within 3h.

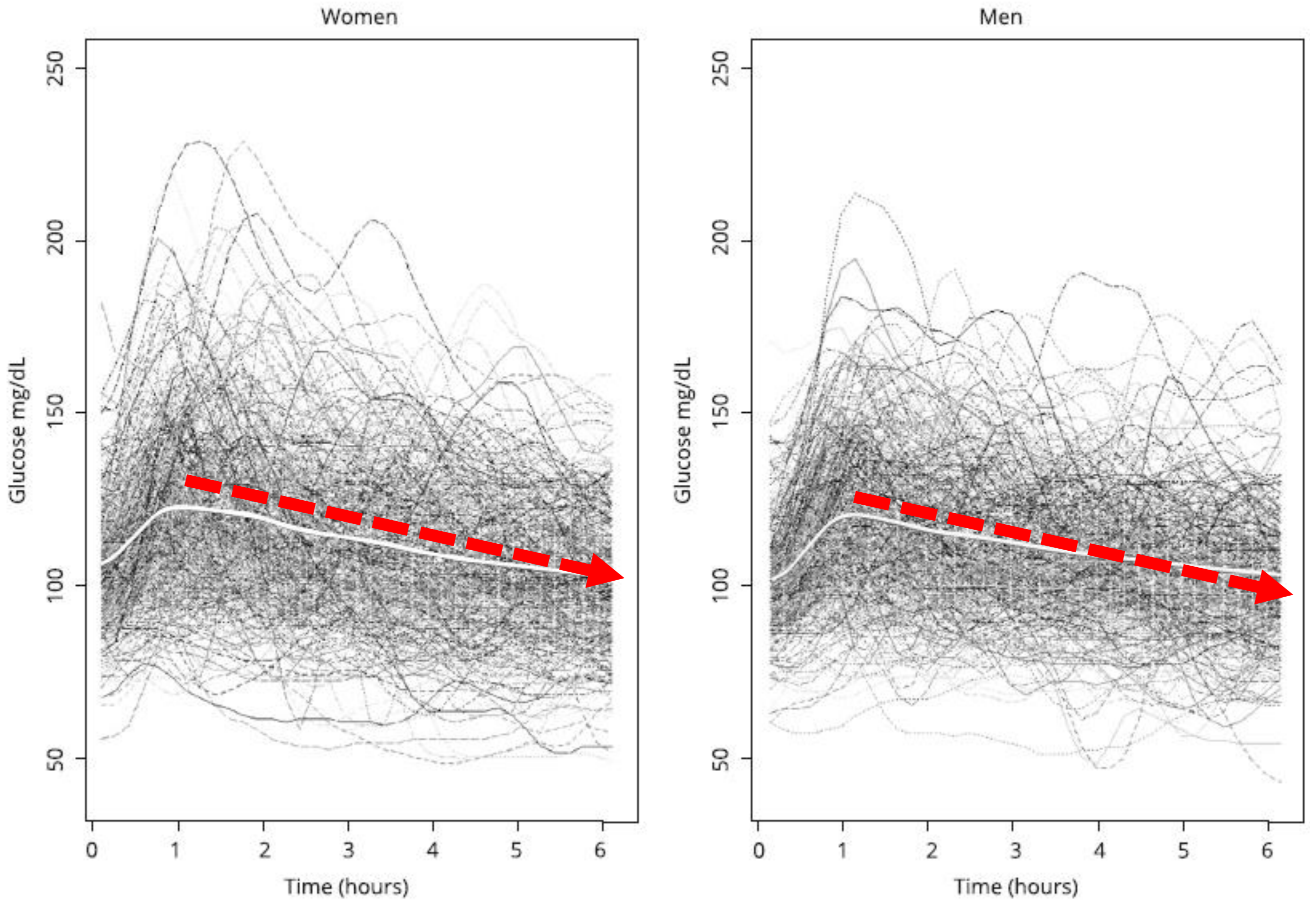
How feeding influences glycemia





Glucose level (mmol/L)
11
5.5
2
Alert warns patient of oncoming hypoglycemia
Prompt action required to avoid hyperglycemia or reduce its duration*
High glucose level alert threshold
Alert warns patient of oncoming hyperglycemia
TARGET ZONE
Low glucose level alert threshold
Prompt action required to avoid hypoglycemia or reduce its duration*
0h
3h
6h
9h
12h
15h
18h
21h
24h

Night glycemia fluctuactions



González-Rodríguez, M., Pazos-Couselo, M., García-López, J. M., Rodríguez-Segade, S., Rodríguez-García, J., Túñez-Bastida, C., & Gude, F. (2019). Postprandial glycemic response in a non-diabetic adult population: the effect of nutrients is different between men and women. *Nutrition & metabolism*, *16*(1), 1-9.

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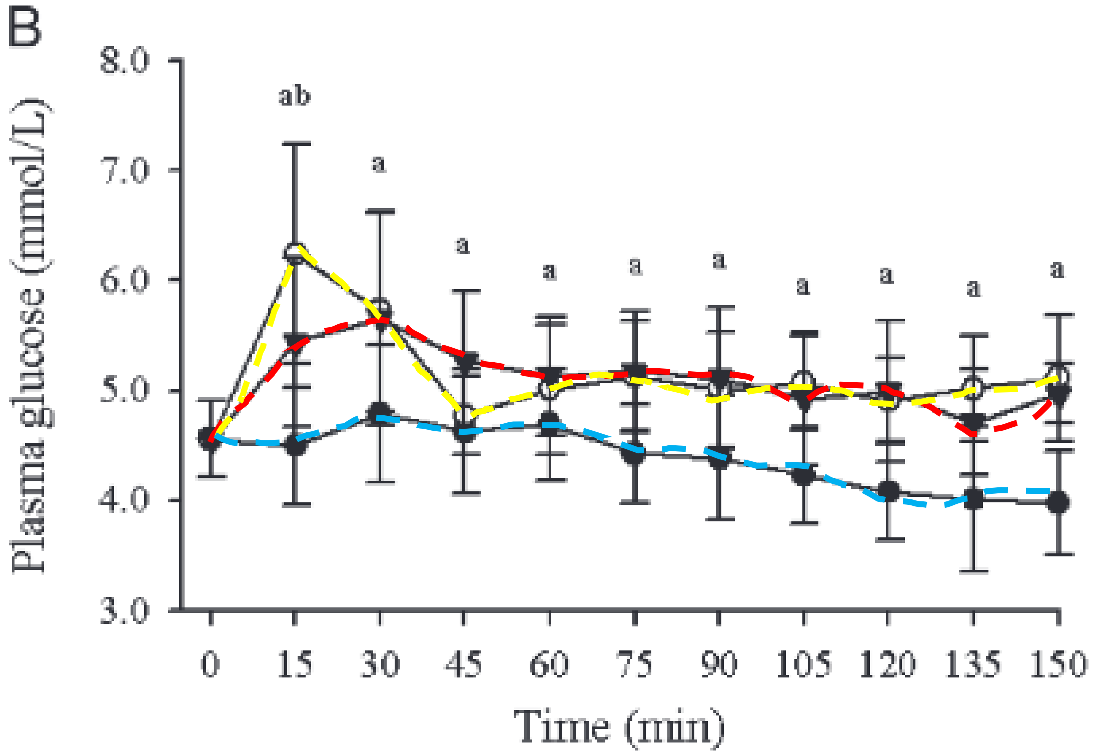


Venables, M. C., Brouns, F., & Jeukendrup, A. E. (2008). Oxidation of maltose and trehalose during prolonged moderate-intensity exercise. *Med Sci Sports Exerc*, *40*(9), 1653-9.

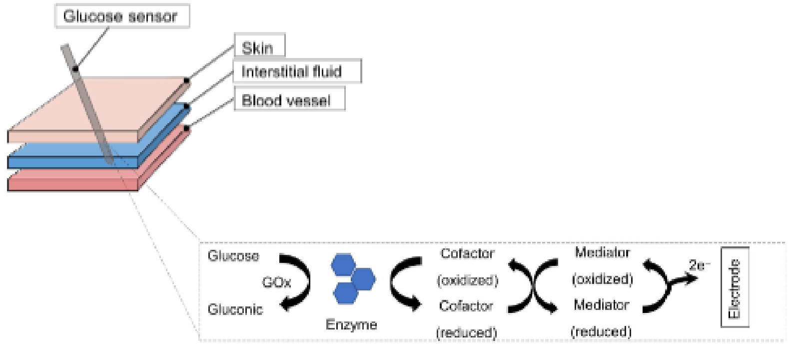
Continuos Glucose Monitoring (GCM)

Continuous measurament of intestitial glucose across 24h-period near real time.

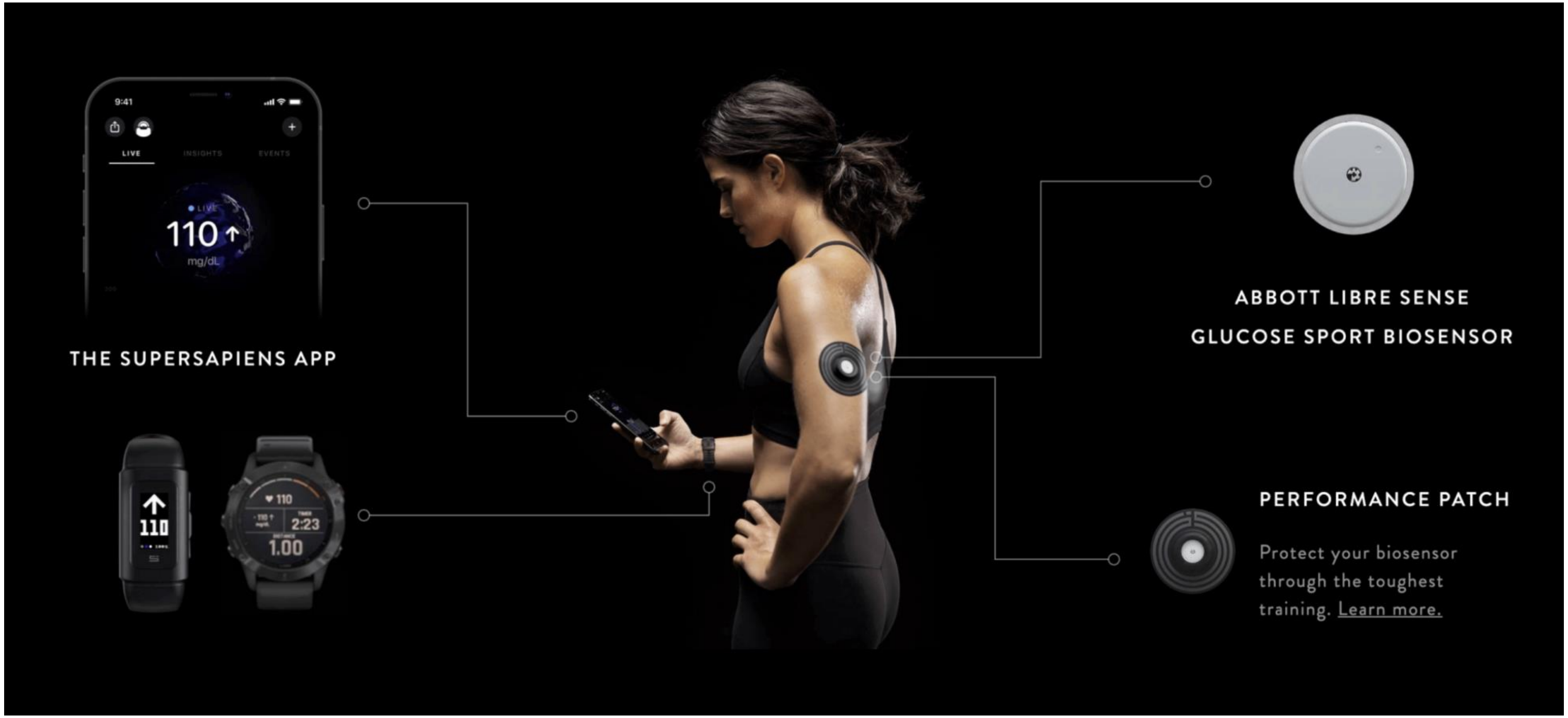
Indwelling sensor inserts into the subcutaneous tissue

Oxidase-soaked electrode that catalyzes the glucose oxidase reaction producing an electrical current that is equivalent to the concentration of glucose in the interstitial fluid.

Interstitial glucose concentration is used to estimate blood glucose throught algorithmic estimations.



Bowler, A. L. M., Whitfield, J., Marshall, L., Coffey, V. G., Burke, L. M., & Cox, G. R. (2023). The Use of Continuous Glucose Monitors in Sport: Possible Applications and Considerations. International Journal of Sport Nutrition and Exercise Metabolism, 33(2), 121-132



Sensor delivers glucose information via wireless technology from a disposable sensor to a smarthphone application automatically or manual swiping on the sensor.

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Use of CGM in endurance sports

- MAINTENANCE OF NORMOGLYCEMIA
- AVOID ABNORMAL FLUCTUACTION
- HEALTH MONITORING

§ 4 Onboard technology

ARTICLE 1.3.006 BIS

"Onboard technology devices, which capture or transmit data, may be fitted on bicycles or worn by riders subject to being authorised under the present article, without prejudice to other provisions of the UCI Regulations. The present article concerns any device which captures or transmits data as described below, including but not limited to sensors (worn or ingested), transponders, rider information systems, telemetry devices.

1. Devices which capture or transmit the following types of data are authorised:

- Positioning: information related to the location of the rider or the bicycle;

- Image: still or moving images or footage captured from the bicycle (such devices may only be fitted on the bicycle unless specific regulations of a given discipline authorise devices being worn by riders);

- Mechanical: information captured from the bicycle or any of its components, including but not limited to power, speed, cadence, accelerometer, gyroscope, gearing, tyre pressure.

2. Devices which capture or transmit the following physiological data are authorised: heartrate, body temperature, sweat rate. The authorisation is, however, limited to transmission protocols which enable only the rider concerned to view the data during a competition.

3. Devices which capture other physiological data, including any metabolic values such as but not limited to glucose or lactate are not authorised in competition.

Continuous Glucose Monitoring of Non-Diabetic Professional Cyclists during a Training Camp

Methods

- 26 professional non diabetic road cyclists (65.7 ± 3.9 kg; 23 ± 3 years; 1.77 ± 0.46m)
- 11-day long training camp in December
- CGM Sensors (Abbott Libre Sense Glucose Sport Biosensor)
- Daily carbohydrate intake was scheduled by medical staff from 3,5 g/kg/BW to 7,2 g/kg/BW according the training load

GLUCOSE-RELATED METRICS ASSESSED:

- **During a 24-hour period (00:00-24:00)**

- The central tendency of the interstitial glucose concentration (average).

- The dispersion of the interstitial glucose concentration (standard deviation).

- **During the overnight period (23:00-06:00)**

-The central tendency of the interstitial glucose concentration (average).

-The dispersion of the interstitial glucose concentration (standard deviation).

-The minimum value of a 3-h rolling average.

-Minutes spent with interstitial glucose concentration <70 mg/dL

Total Daily Energy Expenditure

$$TDEE\ (MJ/day) = BMR * PAL_N + EE$$

- BMR (basal metabolic rate) (MJ/day) = 0.767 + 0.106 * mass (kg)
- EE (energy expenditure) (Kj/min) = 7.497 + 0.237 * power output (Watt)
- PAL_N (non-exercise physical activity level) was set to 1.80

Van Hooren, B., Cox, M., Rietjens, G., & Plasqui, G. (2023). Determination of energy expenditure in professional cyclists using power data: Validation against doubly labeled water. Scandinavian Journal of Medicine & Science in Sports, 33(4), 407-419.

Training Load

Exercise domains were established in three zones:

- **below 70% lactate threshold (LIT);**
- **between 70% and 100% lactate threshold (MIT);**
- **and above lactate threshold (HIT)**

Time was expressed as a percentage of total time spent in the mentioned zones

sRPE (A.U.)= total exercise duration in minutes * RPE

Daily glucose metrics

	Central (mg/dL)	Dispersion (mg/dL)	CHO (g)
Day 1	120 ± 8	19.7 ± 4.7	351 ± 117
Day 2	118 ± 8	20.3 ± 3.7	369 ± 115
Day 3	113 ± 8	17.7 ± 3.2	204 ± 12
Day 4	119 ± 8	21.2 ± 4.0	316 ± 18
Day 5	113 ± 7	18.2 ± 2.8	313 ± 19
Day 6	112 ± 10	19.1 ± 4.1	474 ± 29
Day 7	109 ± 12	17.4 ± 4.3	317 ± 20
Day 8	112 ± 10	18.5 ± 3.6	317 ± 21
Day 9	113 ± 12	21.0 ± 4.2	472 ± 30
Day 10	113 ± 10	18.7 ± 3.4	317 ± 19
Day 11	114 ± 11	22.8 ± 4.9	474 ± 29

Nocturnal glucose metrics

	Minimum (mg/dL)	Central (mg/dL)	Dispersion (mg/dL)	Duration <70 mg/dL (min)
Day 1 to Day 2	95 ± 8	101 ± 7	8.8 ± 3.7	5 ± 21
Day 2 to Day 4	90 ± 7	96 ± 8	9.4 ± 2.9	8 ± 18
Day 3 to Day 4	89 ± 7	93 ± 7	6.5 ± 2.7	0 ± 0
Day 4 to Day 5	90 ± 9	96 ± 9	8.5 ± 3.6	8 ± 26
Day 5 to Day 6	88 ± 8	93 ± 8	7.5 ± 2.9	7 ± 27
Day 6 to Day 7	86 ± 10	90 ± 10	7.0 ± 3.3	21 ± 62
Day 7 to Day 8	86 ± 12	90 ± 12	6.9 ± 3.0	24 ± 85
Day 8 to Day 9	89 ± 11	94 ± 10	7.8 ± 3.1	13 ± 34
Day 9 to Day 10	87 ± 11	91 ± 12	7.2 ± 3.0	35 ± 87
Day 10 to Day 11	86 ± 11	90 ± 12	8.3 ± 3.7	25 ± 59
Day 11 to Day 12	87 ± 10	91 ± 10	7.6 ± 4.2	30 ± 63

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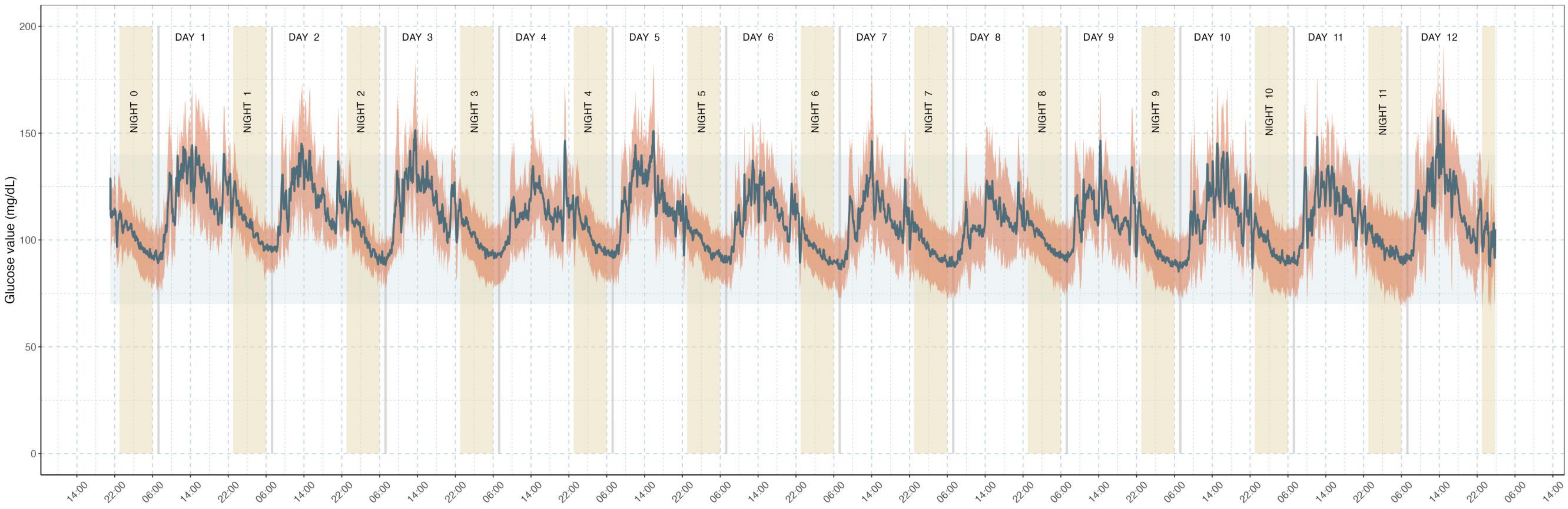
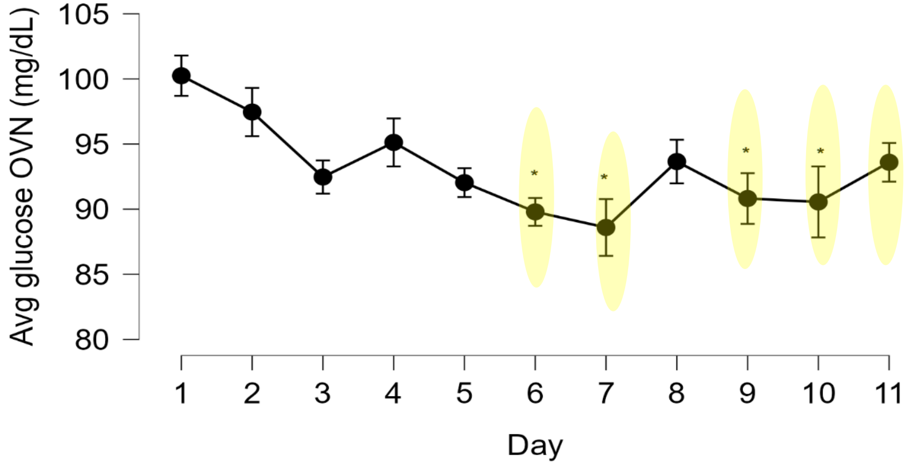
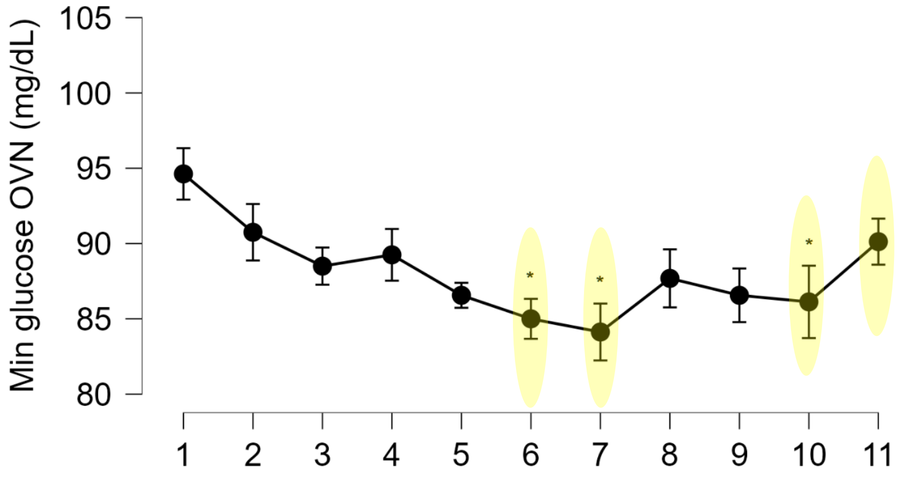
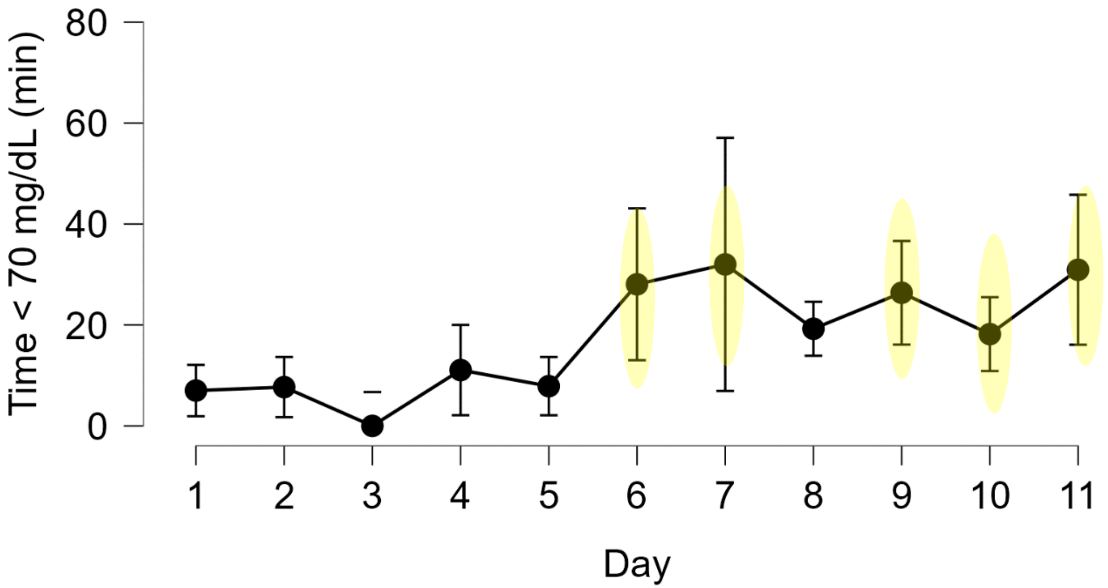


Glucose value (mg/dL)
0
50
100
150
200
DAY 1
DAY 2
DAY 3
DAY 4
DAY 5
DAY 6
DAY 7
DAY 8
DAY 9
DAY 10
DAY 11
DAY 12
NIGHT 0
NIGHT 1
NIGHT 2
NIGHT 3
NIGHT 4
NIGHT 5
NIGHT 6
NIGHT 7
NIGHT 8
NIGHT 9
NIGHT 10
NIGHT 11
14:00 22:00 06:00

Nocturnal glucose metrics







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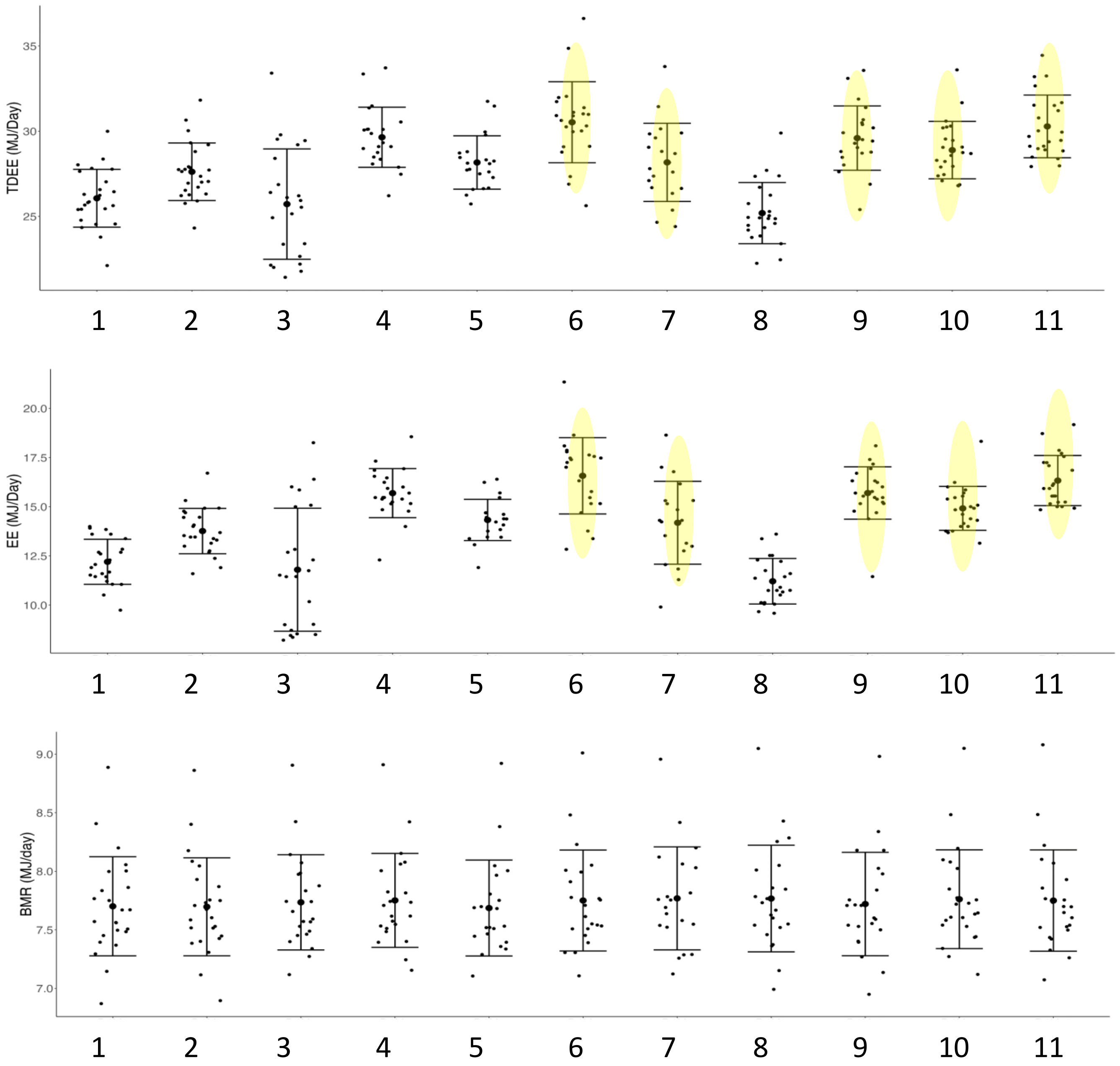

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	Duration (min)	LIT (%)	MIT (%)	HIT (%)	sRPE (A.U.)	Average HR (bpm)	Average relative PO (W/kg)	Average Absolute PO (W)
Day 1	201 ± 66	87 ± 8	8 ± 5	1.68 ± 1.51	991 ± 788	119 ± 12	2.42 ± 0.19	158 ± 15
Day 2	230 ± 19	77 ± 6	16 ± 5	2.96 ± 1.78	1,341 ± 446	129 ± 6	2.74 ± 0.19	179 ± 15
Day 3	49 ± 14	87 ± 21	9 ± 19	2.71 ± 7.81	146 ± 51	130 ± 15	2.80 ± 0.48	183 ± 30
Day 4	326 ± 11	67 ± 7	26 ± 6	2.30 ± 1.21	2,055 ± 511	134 ± 8	3.10 ± 0.20	204 ± 16
Day 5	248 ± 16	76 ± 5	20 ± 4	1.19 ± 1.07	1,218 ± 382	124 ± 8	2.85 ± 0.19	186 ± 14
Day 6	163 ± 27	69 ± 12	21 ± 8	5.59 ± 3.57	876 ± 259	135 ± 8	3.38 ± 0.28	223 ± 21
Day 7	58 ± 21	90 ± 12	8 ± 8	1.91 ± 4.91	177 ± 93	127 ± 16	2.83 ± 0.46	187 ± 28
Day 8	134 ± 3	92 ± 4	6 ± 3	1.32 ± 0.67	261 ± 122	109 ± 6	2.22 ± 0.16	146 ± 16
Day 9	175 ± 14	69 ± 6	25 ± 4	3.13 ± 2.51	839 ± 277	134 ± 8	3.09 ± 0.23	203 ± 18
Day 10	342 ± 15	73 ± 6	20 ± 4	3.77 ± 2.15	2,570 ± 524	129 ± 6	2.93 ± 0.17	194 ± 14
Day 11	290 ± 15	72 ± 7	19 ± 5	6.02 ± 3.08	2,335 ± 558	137 ± 6	3.19 ± 0.20	211 ± 17

Rest day

Hard training day

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Glycemia response in athletes

- Endurance training, especially high intensity training, induces a transient increase of glucose tolerance in elite athletes.
  This phenomenon is due to both a mitochondrial disfunction and blunted insulin response.

- Endurance athletes spend more time in hypoglycemia, especially during sleeping on the night.

Flockhart, M., Nilsson, L. C., Tais, S., Ekblom, B., Apró, W., & Larsen, F. J. (2021). Excessive exercise training causes mitochondrial functional impairment and decreases glucose tolerance in healthy volunteers. *Cell metabolism*, *33*(5), 957-970.

Podlogar, T., & Wallis, G. A. (2022). New horizons in carbohydrate research and application for endurance athletes. *Sports Medicine*, *52*(Suppl 1), 5-23.

Limitations and perspectives

Due to the nature of observational studies, one limitation of the current work is the lack of a more detailed statistical analyses for training related variables that may explain the differences found in several days on CGM-related parameters.

Future research should aim to explore a better statistical approach in order to take into account training and other metabolic parameters.

Conclusions

- The **stability of the interstitial glucose concentration**.
- The relatively **low occurrence of hypoglycemia** across the training camp.
- The time spent with interstitial glucose concentration **<70 mg/dL** was **minimal,** particularly during the **overnight period (23:00-06:00)**, suggesting that the athletes maintained adequate glucose control during the resting period.

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Thank you for your attention

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