

Adjusting bolus insulin on pump therapy (CSII)

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Disclosures

- I and my research department have received educational speaker fees, and advisory board fees, from Abbott, DEXCOM, Lilly, NovoNordisk, and Sanofi.

Learning objectives

- Understand the desired effect of bolus insulin on glucose levels
- Feel more confident adjusting bolus insulin in response to FreeStyle Libre traces
- Understand which factors change bolus insulin requirements



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Bolus insulin

The role of bolus insulin is to:

- Cover the glucose rise whenever carbohydrate is consumed (eaten or drunk)
 - For this to work well you need to know your insulin to carbohydrate ratio (I:C ratio) at each time of day, for example:
 - 1.5 units per 10 g (or 1 CP) at breakfast
 - 1 unit per 10 g (or 1 CP) at lunch and in the evening
- And, to correct a high blood glucose (BG)
 - For this to work well you need to know your correction factor, also known as insulin sensitivity factor (ISF), for example:
 - 1 unit to lower BG by 3 mmol
 - (this may also vary according to the time of day)



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Bolus insulin

- Your pump only contains a quick acting insulin, examples are Humalog, Novorapid, Apidra and FiASP.
- Bolus doses take 3 to 4 hours to have their full effect.
- This is known as the action time – this value is programmed into your pump
- **Remember** – all boluses take time to be absorbed and to have any effect on BG



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Assessing bolus insulin

Assessing I:C ratios
(insulin : carbohydrate)

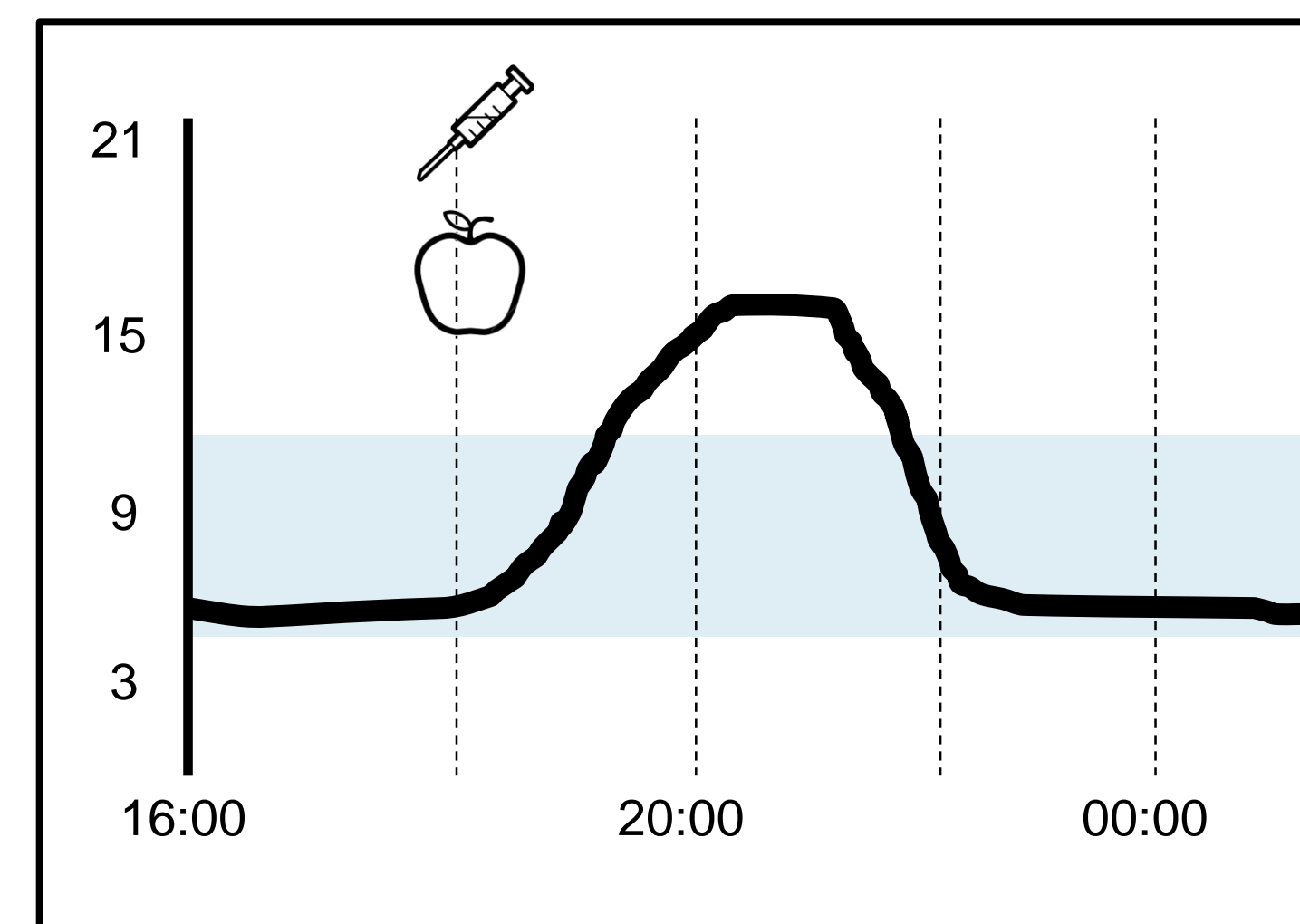


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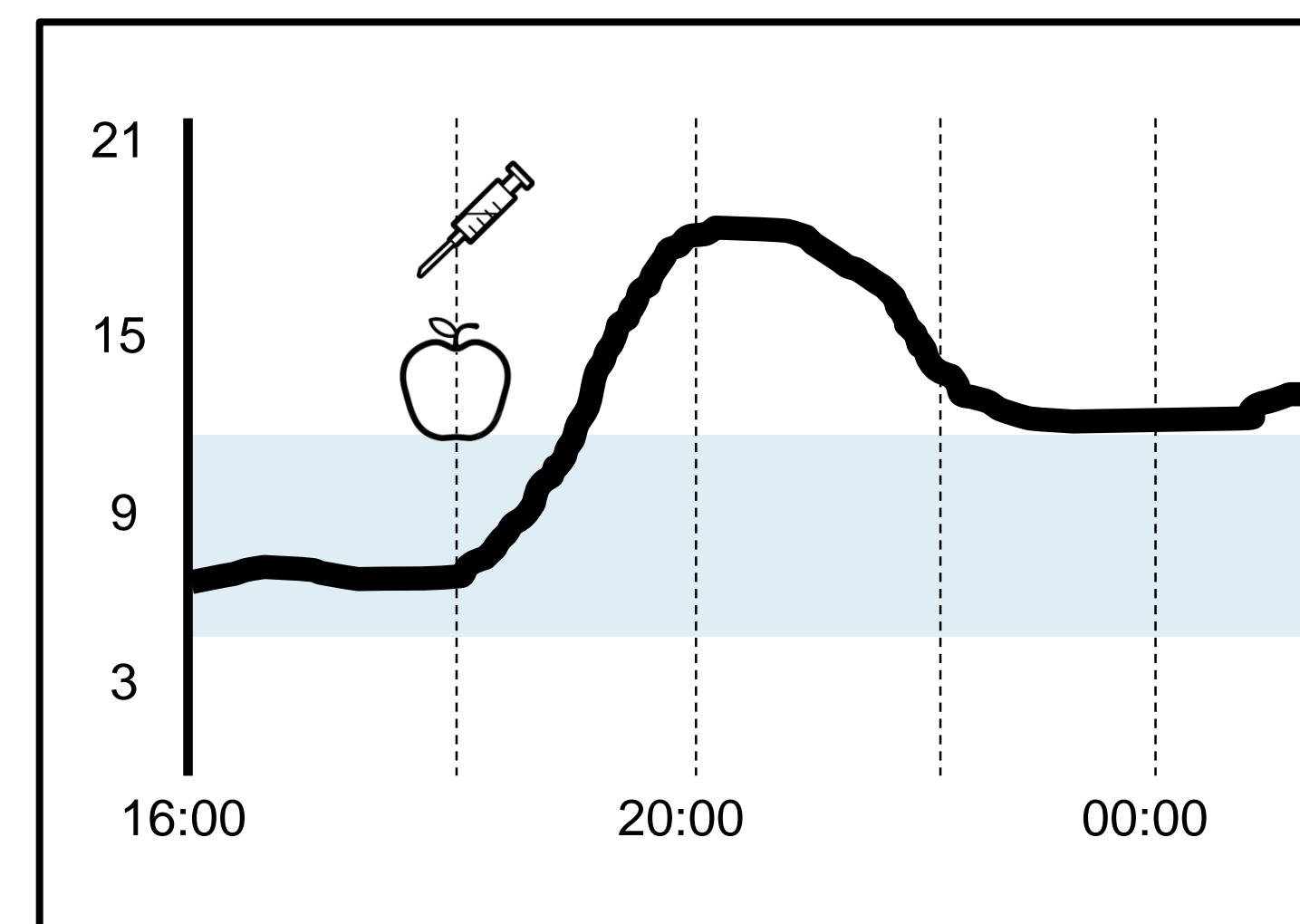
I:C ratio correct

- To assess the I:C ratio for a mealtime, check if the BG beforehand is in target and then again 3-4 hours later
- If the I:C ratio is correct, the glucose level should return to target levels within 4 hours
- This will only be the case if the I:C ratio is correct for that mealtime and if the carbohydrate counting is accurate



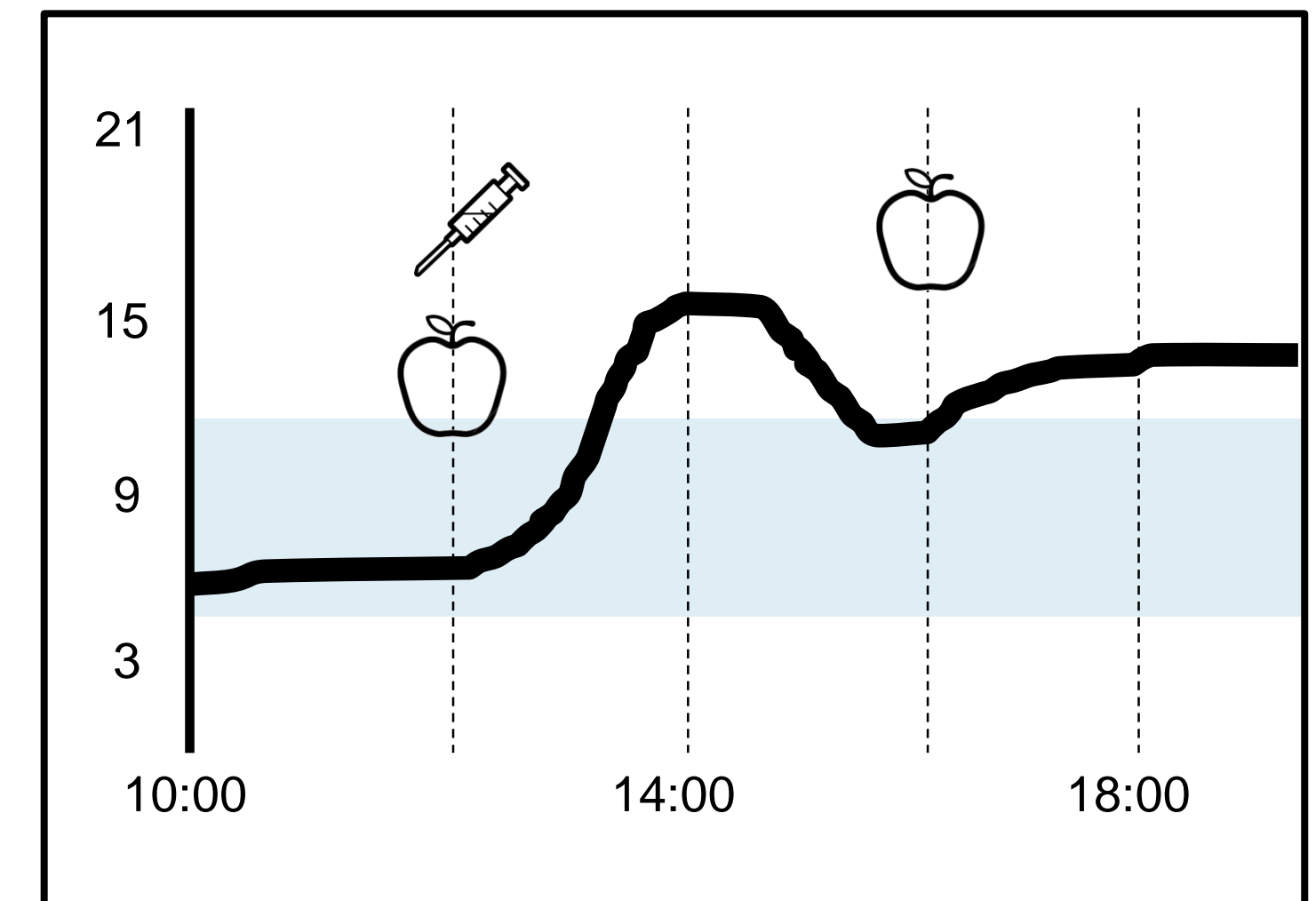
I:C ratio too low

- If the I:C ratio is too low in the evening, the glucose will **remain high all night**, (unless it is corrected before bed)
- This can also happen if the carbohydrate has been underestimated, or snacking post meal



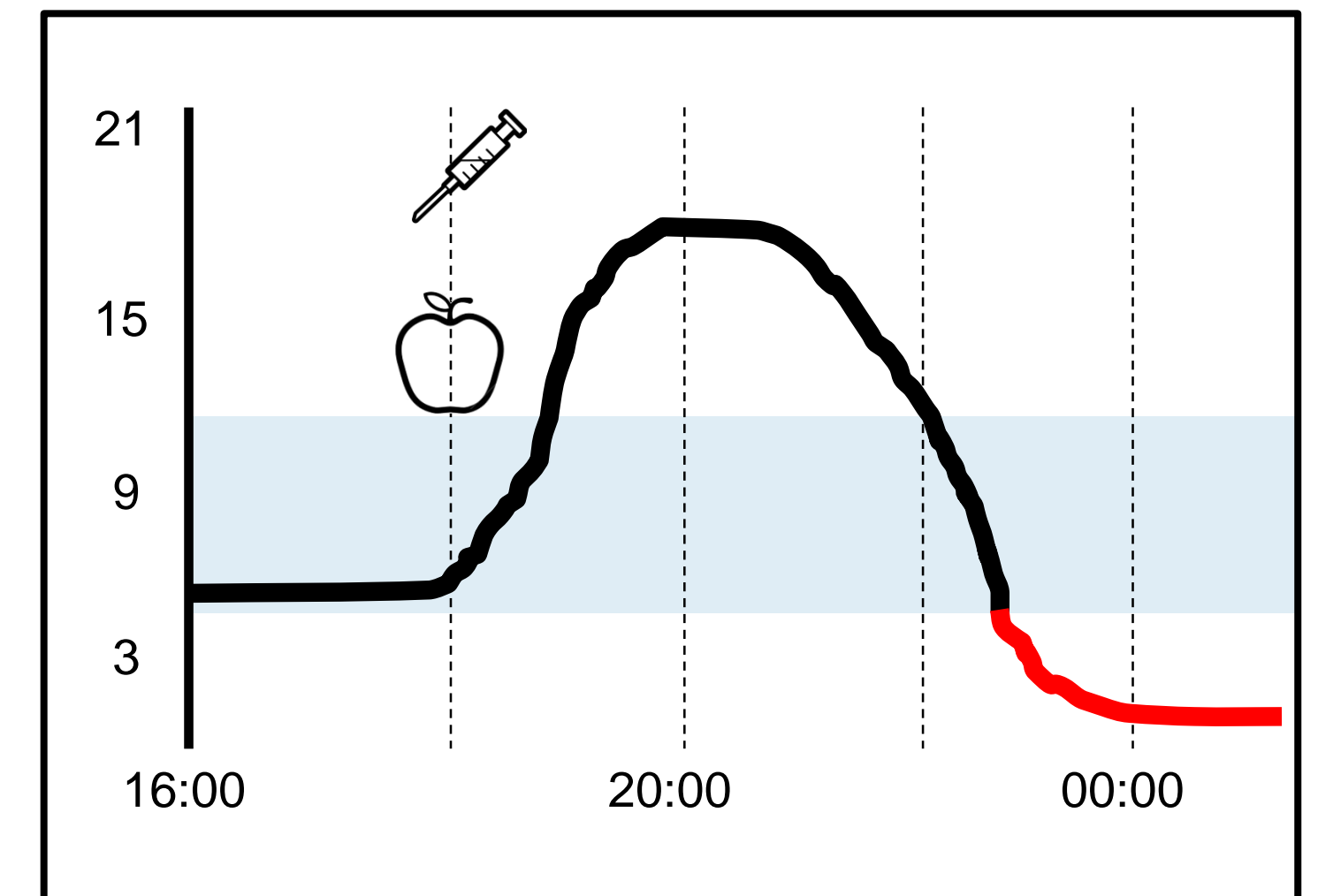
Snacking

- If you snack post meal then this too will need bolus insulin to cover it, otherwise BG will go up.
- There are 2 choices, either
 - Give an extra bolus of insulin with the snack
 - Or, if you regularly snack after a meal, add the carbohydrate content of the snack to the meal beforehand



I:C ratio too high

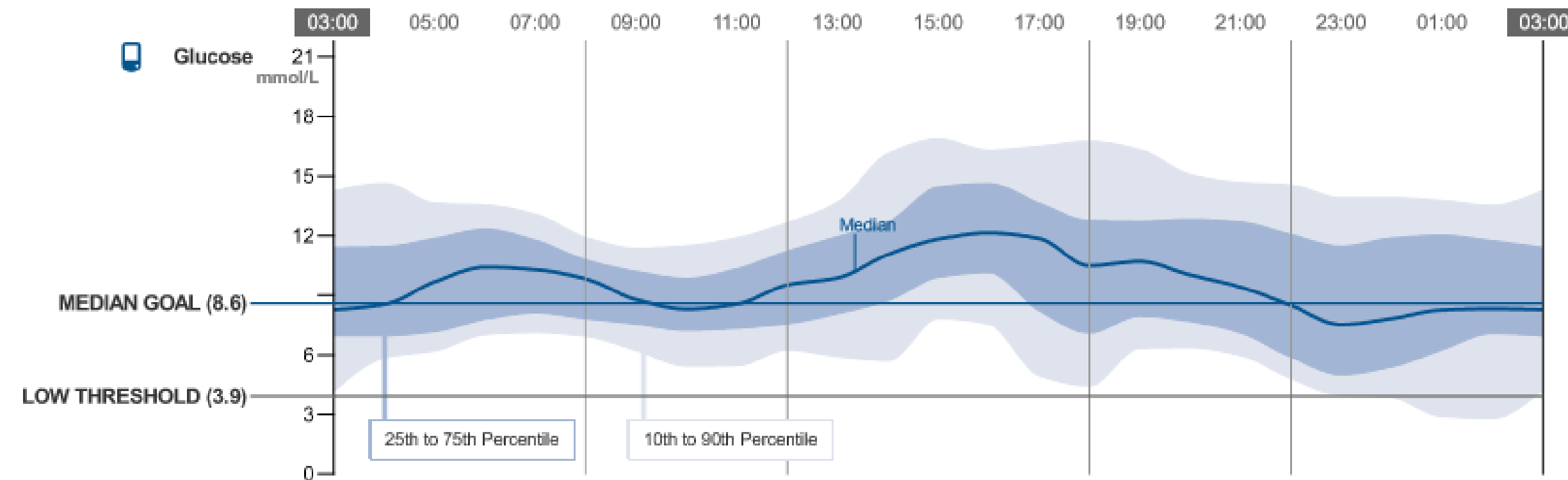
- If the I:C ratio is too high in the evening, the glucose will **remain low all night**, unless the hypo is treated before bed



Which ratio(s) is too low?

SETTING: 8.6 mmol/L (A1c: 7.0% or 53 mmol/mol)

Estimated A1c **7.8%** or **62 mmol/mol**



- The AGP is only a guide, it is best to look at individual days

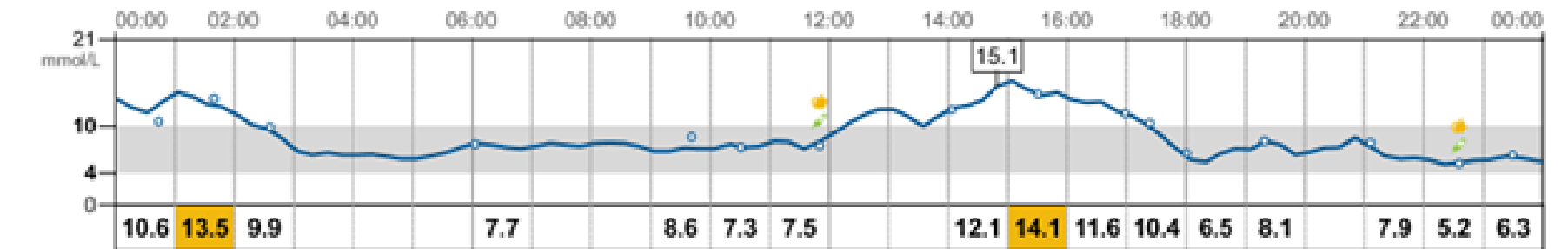
Thu 4 Feb

Glucose mmol/L

Carbs grams

Rapid-Acting Insulin units

Long-Acting Insulin units



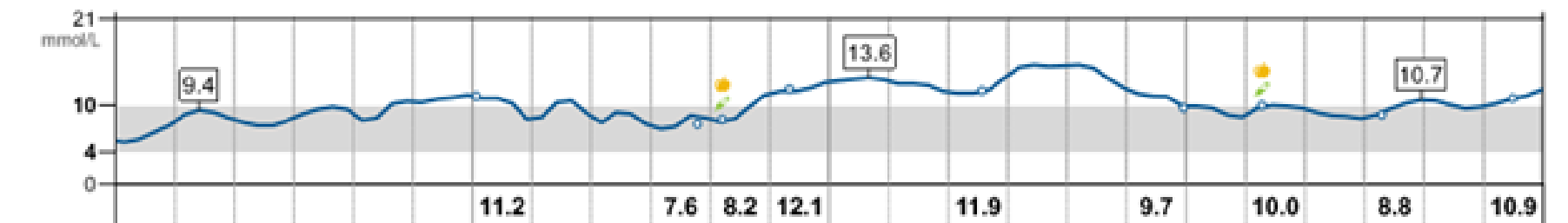
Fri 5 Feb

Glucose mmol/L

Carbs grams

Rapid-Acting Insulin units

Long-Acting Insulin units

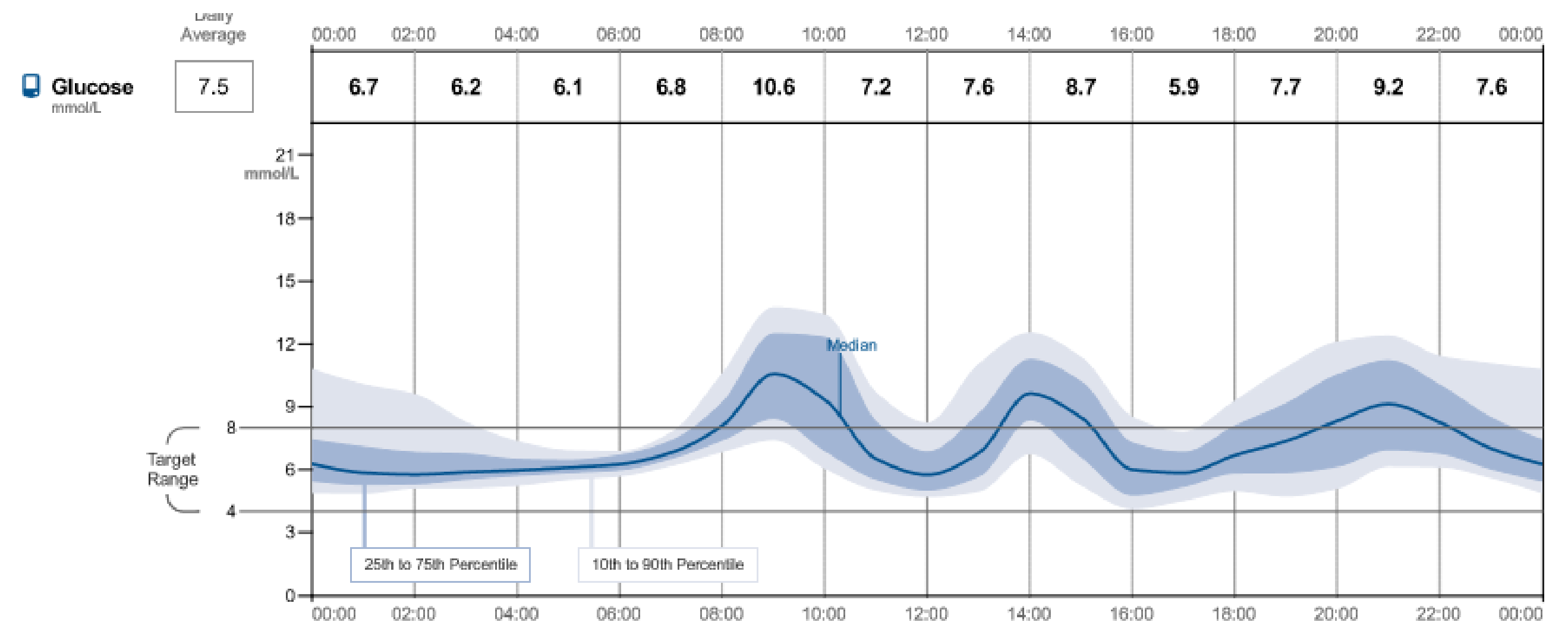


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When should you bolus?

- If you bolus at the time of eating there will be a large peak at each mealtime, as it takes time for QA insulin to be absorbed
- When are the mealtimes in the example below?

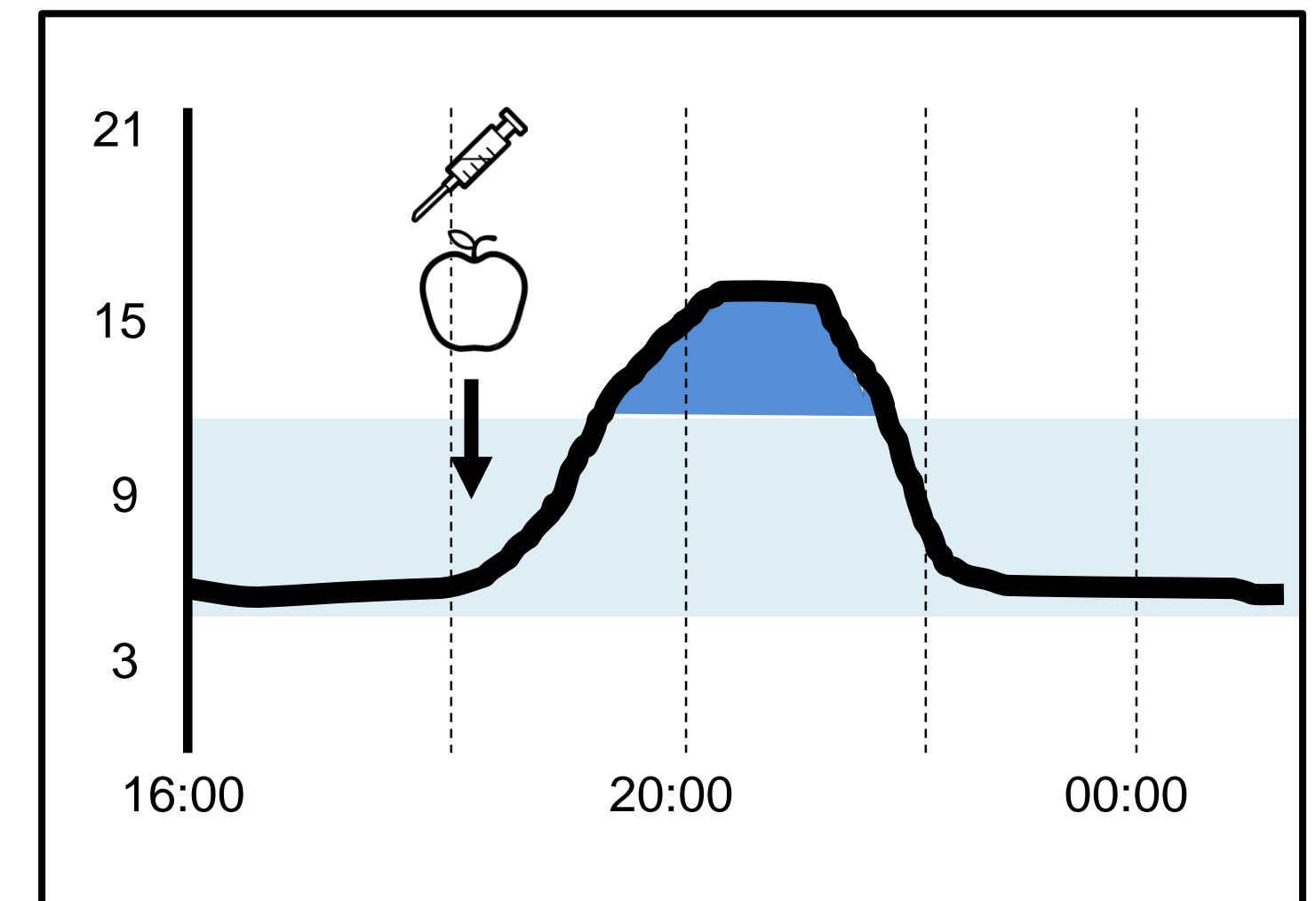


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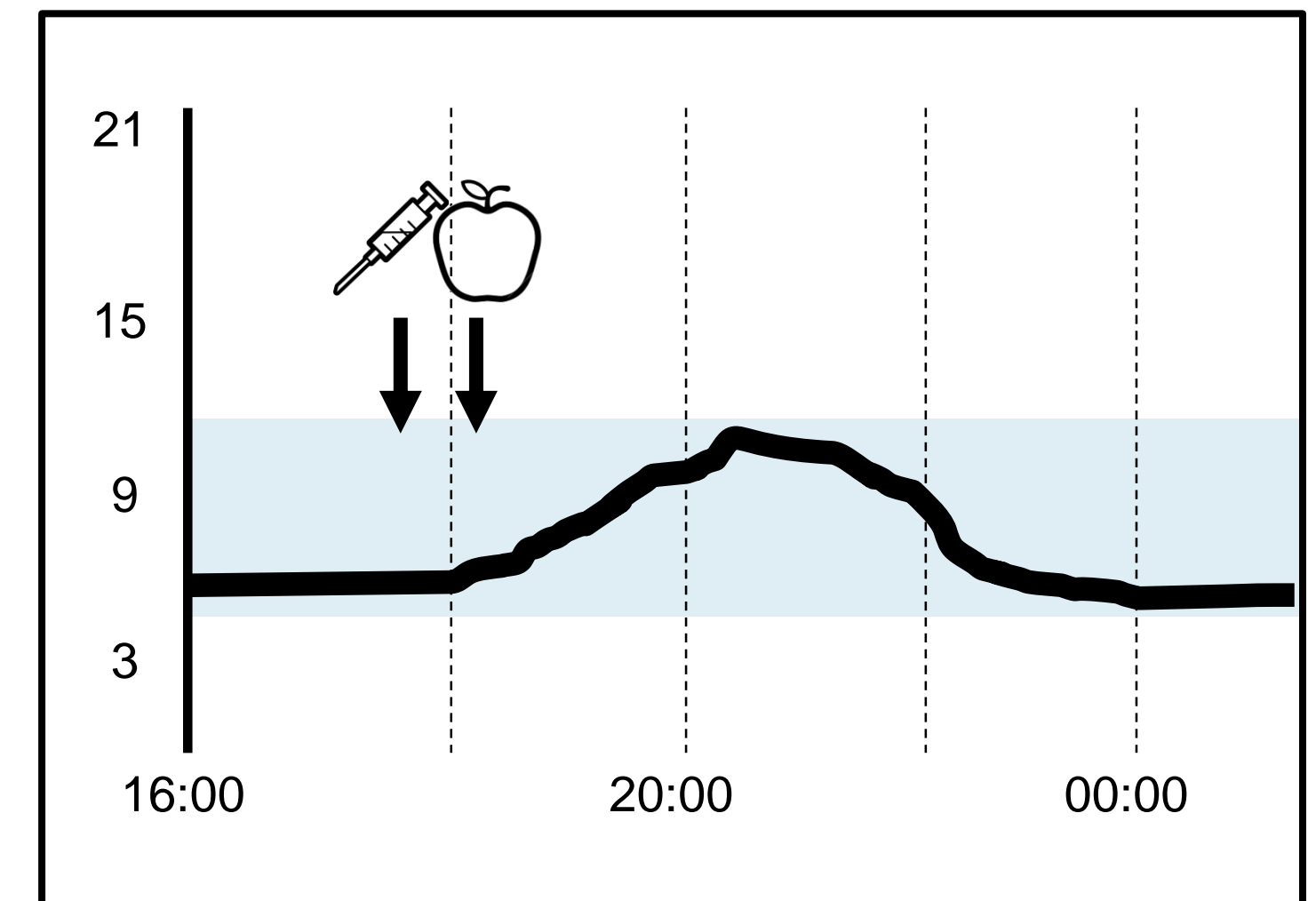
When should you bolus?

- If you bolus at the time of eating this increases the amount of time your BG is above 10, and therefore outside the target range, area shaded blue in diagram below, over time this will raise your HbA1c



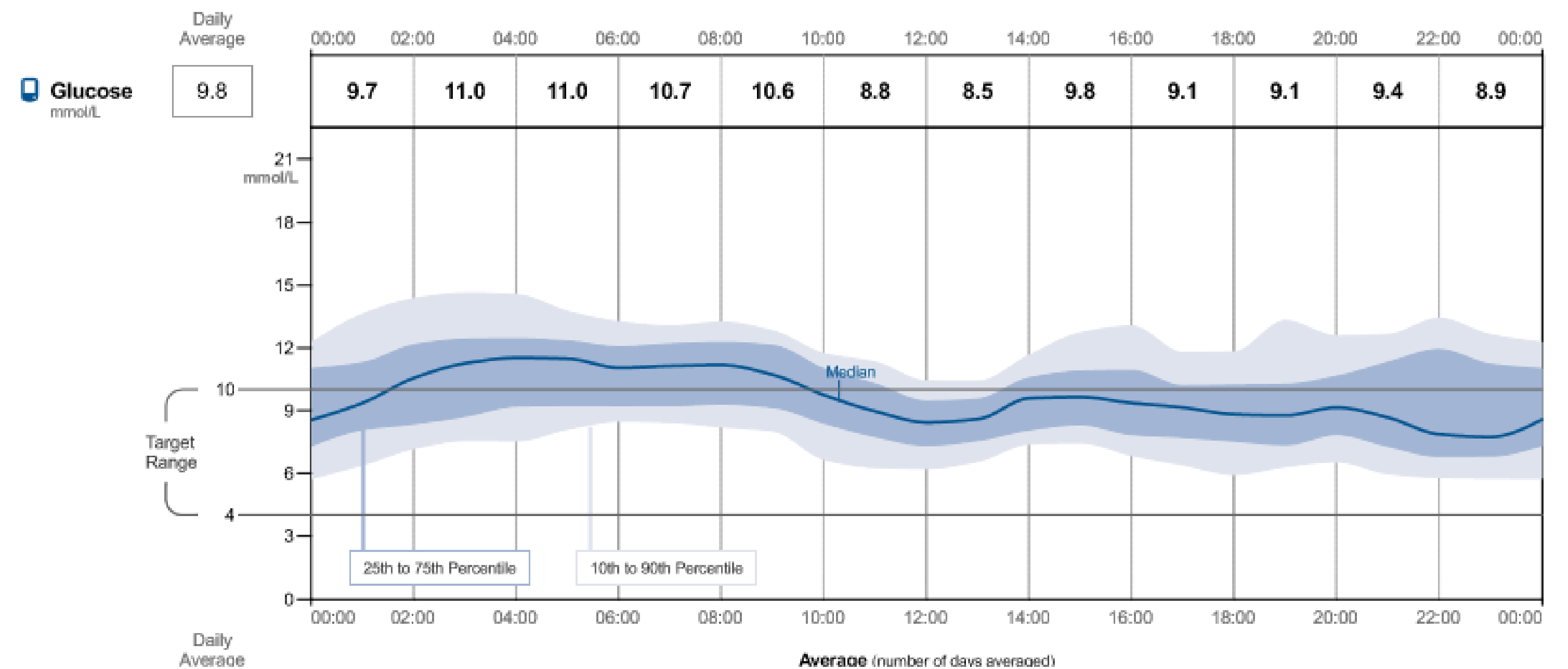
When should you bolus?

- If you bolus at least 15 minutes before meals, then the peak is not as tall, and the time spent outside the target range may be zero or very small.



When should you bolus?

- When are the mealtimes in the example below?
- Answer - the same as the last slide, it is the same person, but they have moved their injections to 15-20 mins before mealtimes.



Assessing bolus insulin

Assessing correction factors / ISF

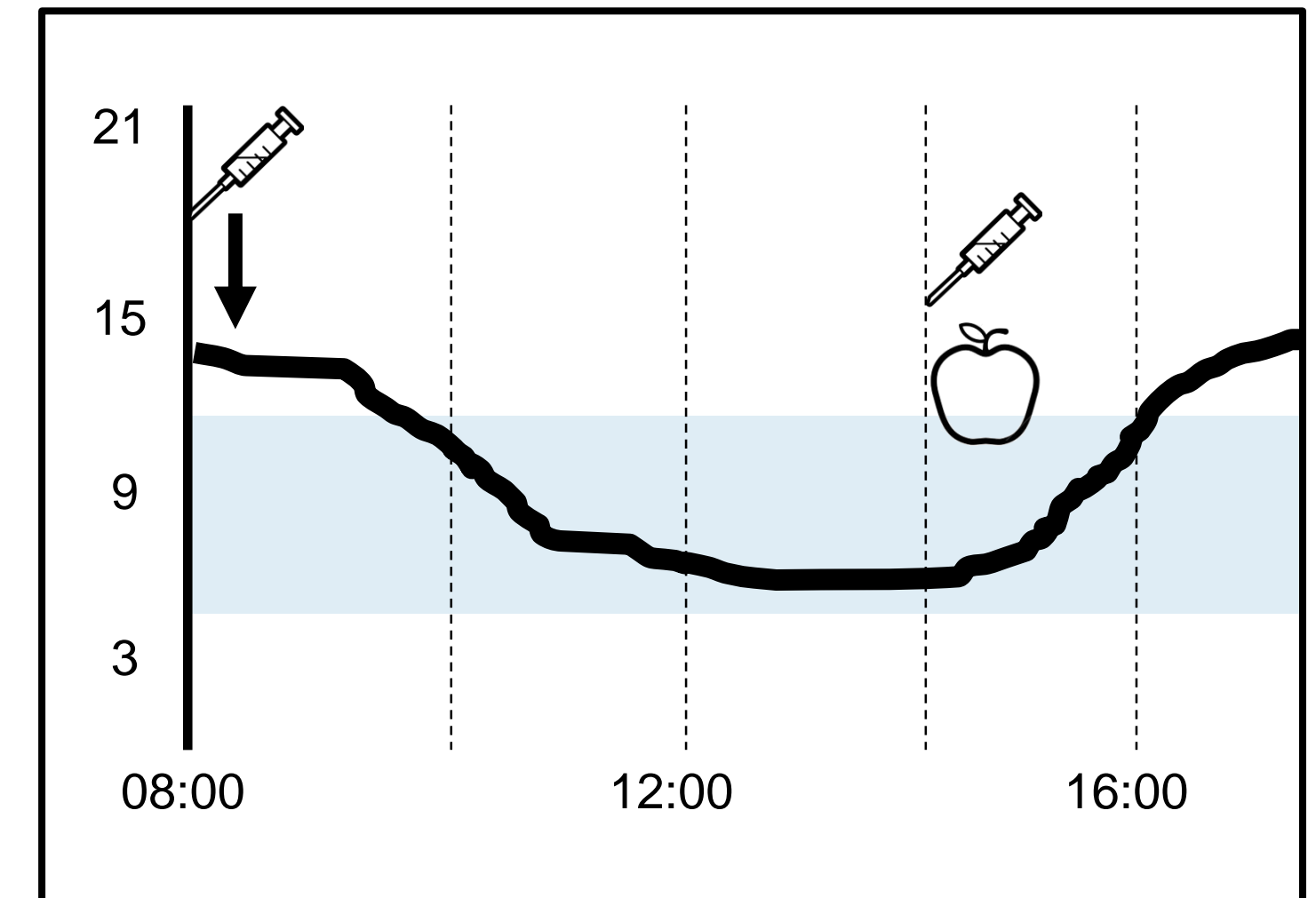


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Corrective doses

- For example, this libre user does not eat breakfast, but the corrective dose of 5 units on waking has brought the BG back into the target range by midmorning, from 15 to 5. Their correction factor (ISF) is 1 unit to lower BG by 2 mmol/L.



Corrective doses

Expected drop in BG = correction factor (ISF) x number of units of bolus insulin

Pumps will have a target BG pre-programmed into them, so:

$$\text{Number of units of bolus insulin} = \frac{\text{BG} - \text{target BG}}{\text{Correction factor (ISF)}}$$

If the correction factor (ISF) is set too low, e.g., 1.5, then more bolus insulin than is required will be delivered each time the pump corrects a high BG, causing hypos

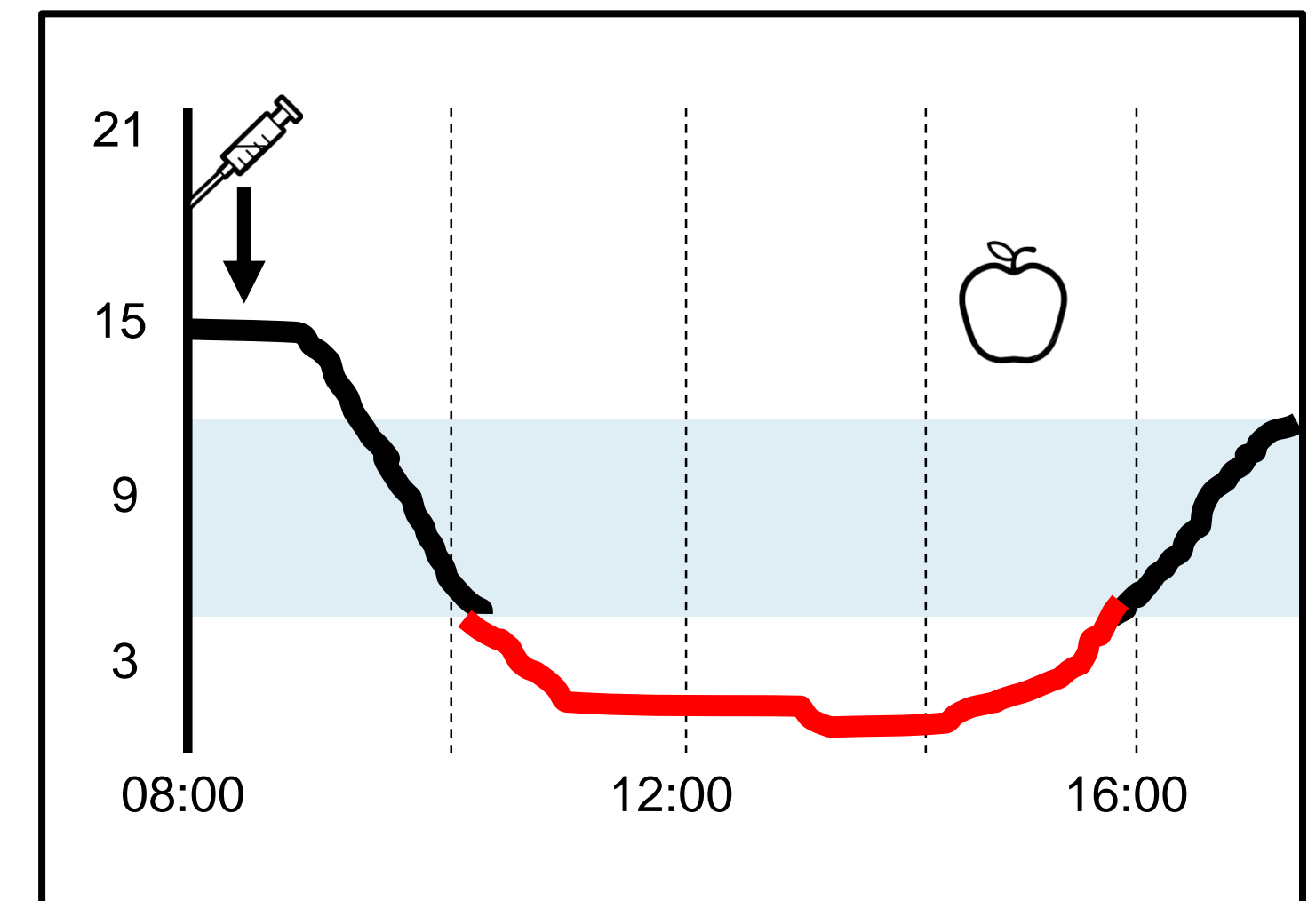


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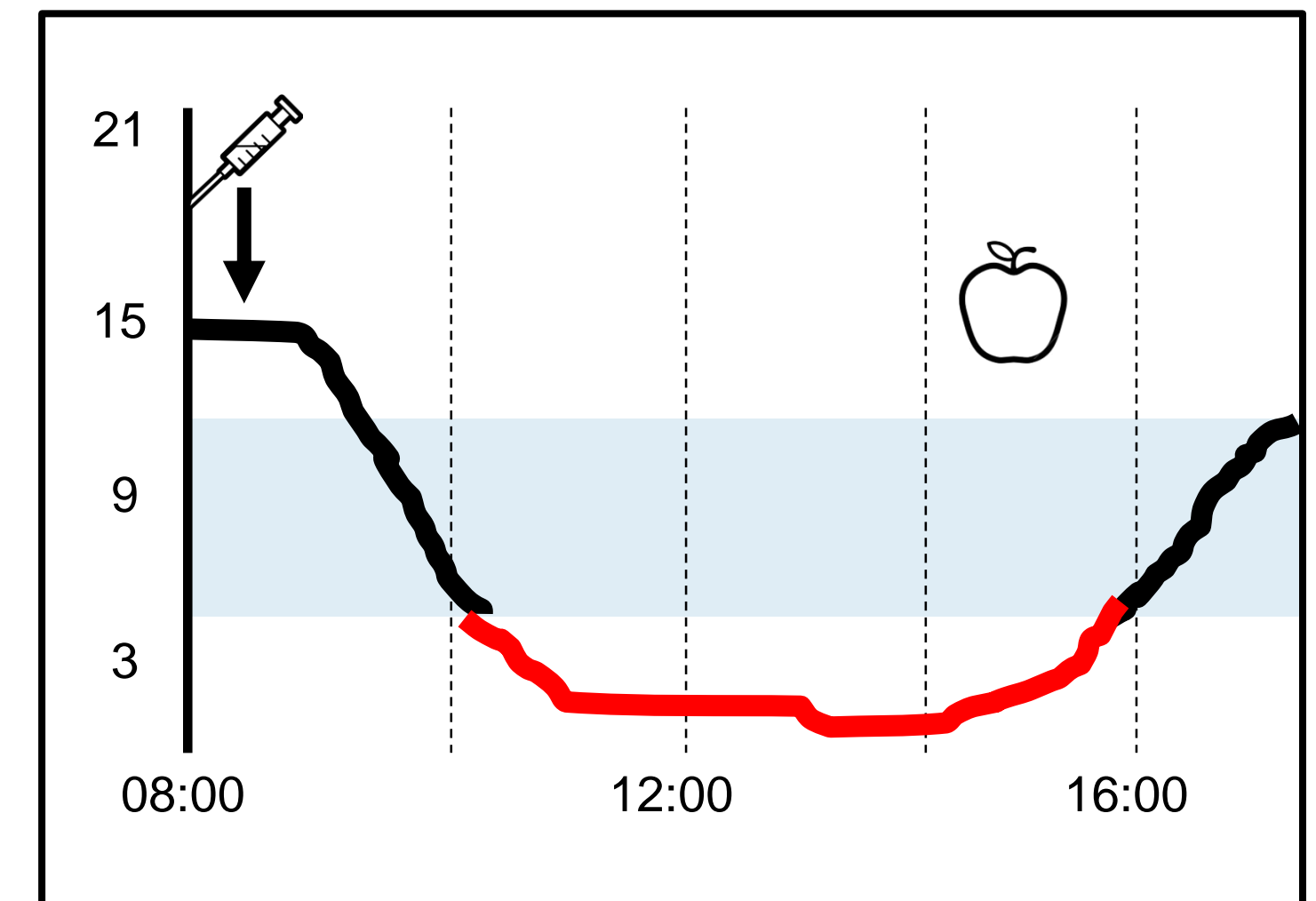
Correction factor too low

- For example, this libre user does not eat breakfast, but the corrective dose of 5 units on waking has made them hypoglycaemic by mid-morning, their BG has dropped from 15 to 2.5, their correction factor is 1 unit to lower BG by 2.5 (not 2 as they thought).



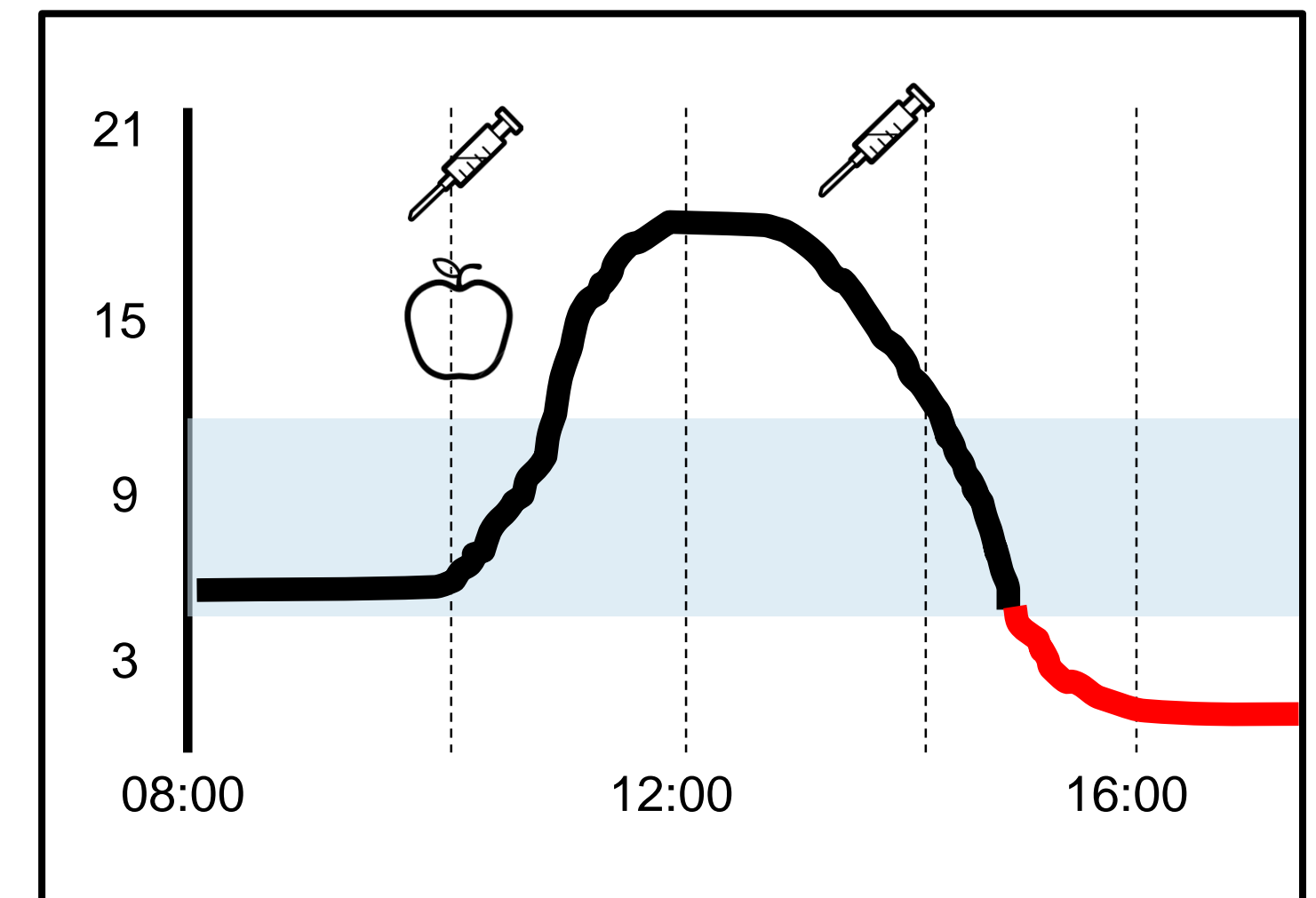
Correction factor too low

- If your correction factor is too low you will have more hypos than you should. This can lead to:
 - Weight gain, because you end up consuming more carbohydrate than you really need, and it
 - Also can lead to impaired warning of hypoglycaemia



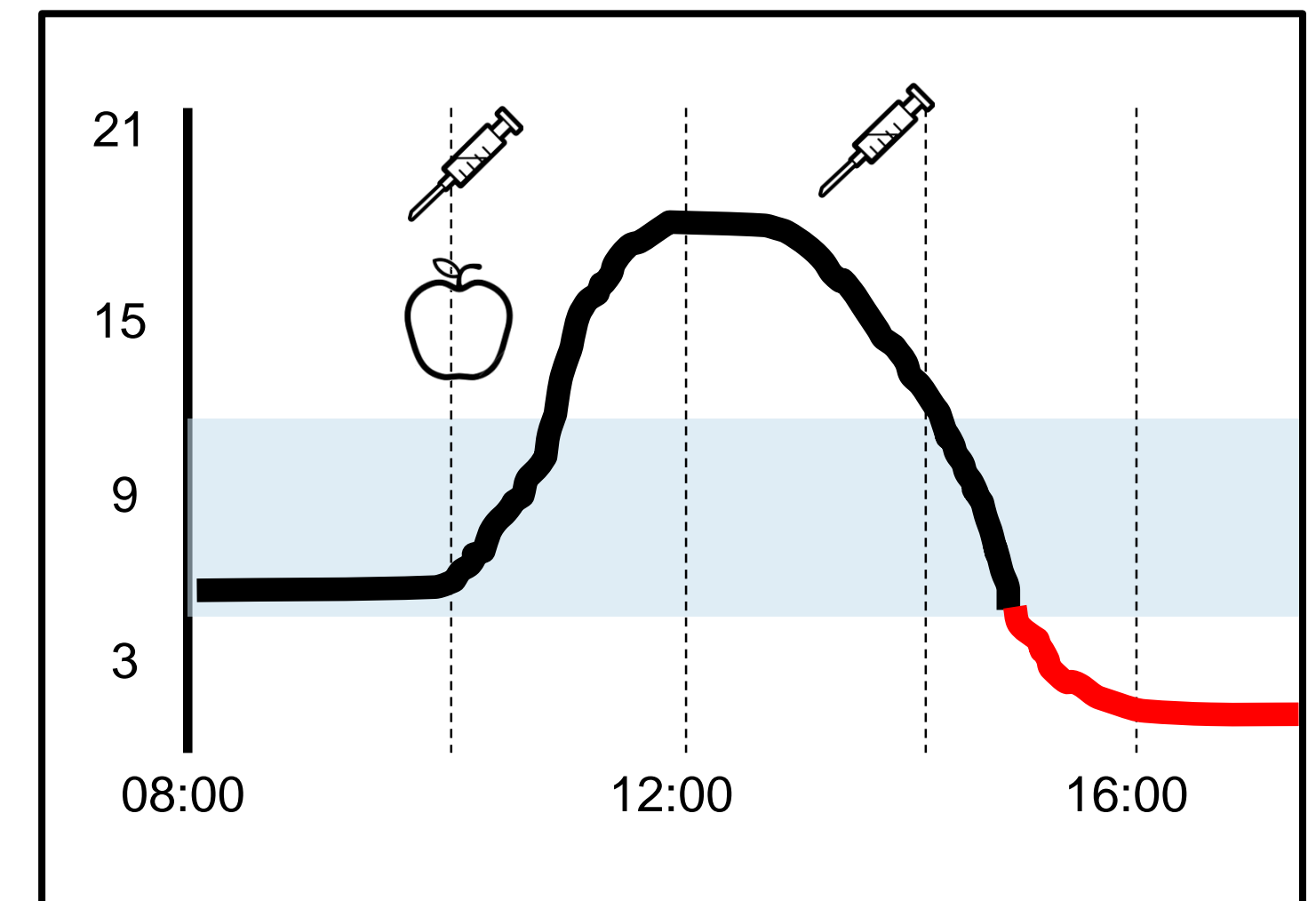
When should you correct?

- It is usually best to only correct at least 2-3 hours after the last bolus.
- This allows for most of the bolus to have had time to work.
- What is the problem here?



When should you correct?

- If you correct whilst the previous bolus is active then the 2 boluses will overlap. This can result in unnecessary hypoglycaemia if the settings in your pump are not quite right for you. If this is happening regularly you will need to reassess I:C ratios and correction factors (ISF).



Turbulence in bolus requirements

Exercise alcohol recent hypo



Inaccurate carbohydrate counting

Stress illness high fat meals



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Difficult situations

- You may need to reduce bolus insulin in some situations, for example by halving the I:C ratio if:
 - Exercise before eating
 - Exercise after eating
 - After alcohol
 - Recent hypo



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Difficult situations

- You will need to increase bolus insulin in some situations, for example by increasing the I:C ratio by 10 to 20% if:
 - Stressed
 - Ill
 - High-fat meals (fish and chips, pizza, takeaways)
 - Pre-menstrual



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Conclusions

- FreeStyle Libre allows you to see the effect of different foods on the BG
- Bolusing QA insulin 15-20 mins before meals will mean
 - The peaks in BG will be smaller,
 - The time in range of 4-10 mmol / L will increase,
 - In time, your HbA1c should improve



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Conclusions

- If your BG is always high after a particular mealtime that suggests your I:C ratio is too low (assuming your basal insulin is not too low).
- If you are often hypo at the same time of day, when you are in target pre-meal, this suggests your I:C ratio is too high (assuming your basal insulin is not too high).
- It is always best to look for patterns before changing a I:C ratio, or correction factor (ISF).



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Conclusions

- If there are no regular patterns check that your carbohydrate counting is accurate.
- Working out your I:C ratio for each mealtime, and correction factor (ISF), will mean you are injecting the right amount of bolus insulin more often.



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