

Ten steps to improve control in type 1 diabetes

For insulin pump patients



More control
Fewer surprises
Fewer hypos
Fewer highs

Why is it important to achieve good blood glucose management?

Perhaps the biggest reason is that people who have more predictable, 'on target' blood glucose readings tend to feel better and diabetes becomes less of a burden on quality of life. In the long-term, good diabetes control results in a hugely reduced risk of developing complications, including a significantly reduced chance of developing cardiovascular disease. The beneficial effects of good diabetes control last for several decades.

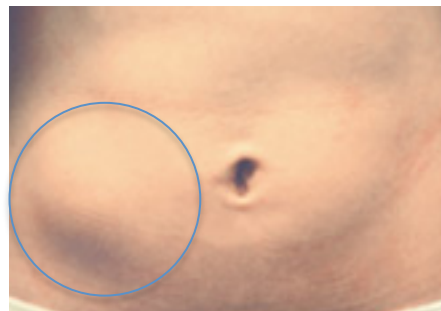
Targets

Blood glucose targets should be individualised and agreed between patient and doctor / nurse specialist. Below is a suggested set of target glucose readings for patients with type 1 diabetes:

Time	Target glucose
Before breakfast	5.5 – 7.5 mmol/L
Before other meals	4.5 – 7.5 mmol/L
2 hours after meals	Less than 10 mmol/L
Before bed	6.5 – 8.0 mmol/L

Infusion sites and lipohypertrophy

It is difficult to over-emphasise the importance of rotating infusion sites. Lipohypertrophy (fatty lump caused by infusing insulin into the same site repeatedly) can be an issue with pump use, just as it can be with injections. Lipohypertrophy is important as it can affect the absorption of insulin and result in unexplained highs and lows, the pictures below are extreme examples and it is worth feeling over your infusion areas to ensure there are no lumpy areas. It is recommended, during a set change, that the next insertion site should be 2 – 3 inches (5 – 8 cm) away from the previous site.



It is typical to recommend a set change every three days. Leaving it longer can result in less absorption of insulin and therefore higher blood glucose levels. You may find control is different between day 1 and day 3 of your set use – if this is a significant issue it may be worth considering more frequent set changes.

How often should I check my blood glucose levels?

It is difficult to achieve good, safe control of type 1 diabetes with any fewer than 4 blood glucose tests per day. Indeed, when adding in driving, sport, avoiding hypos and stressful events, it may be difficult to achieve control with any fewer than 6 or 7 tests per day. We realise that for many people this is not something they can manage on a daily basis and, in that situation, checking frequently every now and then is better than not at all. This guide has been designed to help convert the information gained from regular glucose testing, into actions that will make your diabetes more predictable and easy to manage in the long-term.

Should I keep a diary?

It can be useful, during spells of 'intensive glucose monitoring' to keep a detailed diary, which takes in to account exercise, food intake, insulin doses and bolus timing. You can pick up an 'intensive monitoring diary' from the clinic or download a copy from the clinic website:

www.edinburghdiabetes.com/intensive-diabetes-control

For the most part, it is probably more useful to upload your pump (and/or glucose meter) and review the results on your home computer (see step 9, page 13 for more details on how to do this).

Glossary of terms used in this booklet:

Active insulin: This is an estimate of how long your bolus insulin acts for – it is typically set at between 3 and 4 hours.

Carbohydrate portion: This is the unit used by the DAFNE course and is the same as 10 grams of carbohydrate.

Correction factor (insulin sensitivity): The fall in glucose you would expect to see for each unit of insulin injected (e.g. 1 unit lowers 2 mmol/L).

Hypoglycaemia: A low blood glucose level (typically defined as less than either 4 or 3.5 mmol/L).

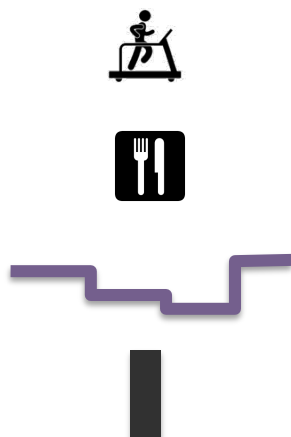
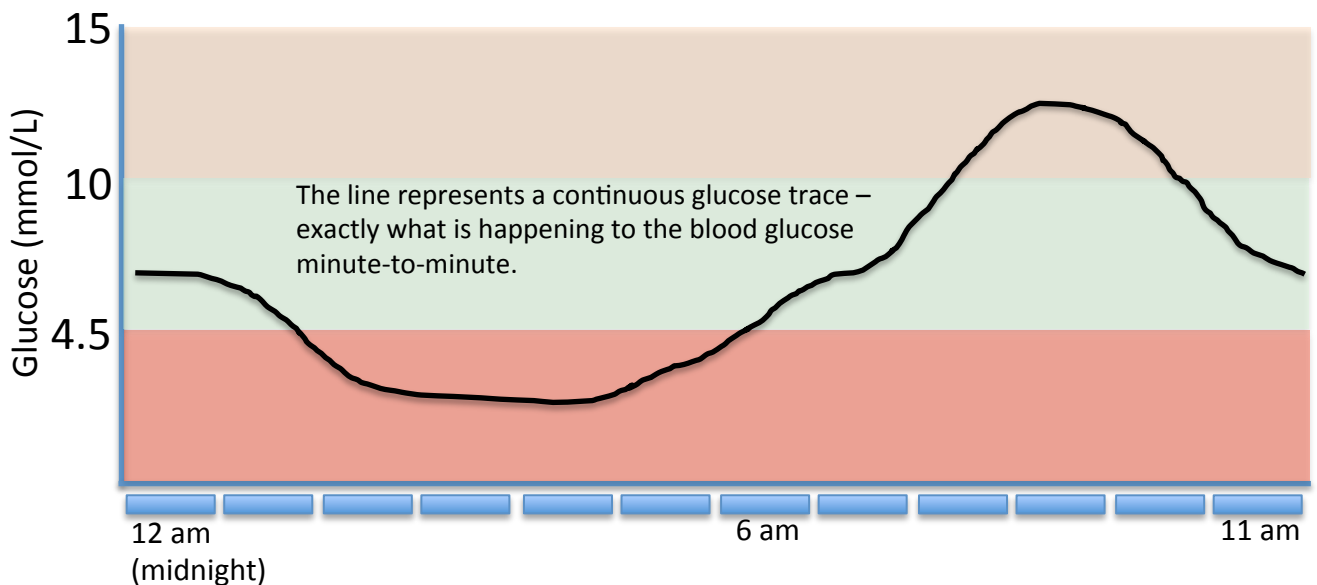
Insulin:carbohydrate ratio: The amount of insulin required to match carbohydrate intake. A ratio of 1:10 would mean taking 4 units to cover a meal with 40 grams of carbohydrate. A ratio of 1:5 would mean taking 8 units to cover 40 grams of carbohydrate.

Temporary basal rate: The ability to increase or reduce the basal by a specified percentage (e.g. 80% of the usual insulin rate [or to put it another way, 20% less insulin]). This can be useful in relation to exercise, illness, stress and pre-menses(periods). If you do not know how to set temporary basal rates please contact us.

Ten Steps

1. Avoiding overnight hypos
2. Getting the morning glucose on target
3. Sorting out the basal infusion rates
4. Matching bolus doses to meals
5. Getting the bolus timing and type right
6. Getting the correction factor right (and not overusing it)
7. Treating hypos appropriately
8. Dealing with exercise
9. Periodically review your patterns (and share them)
10. Use your diabetes clinic to suit you

An explanation of the figures used in this booklet:



Exercise

Food intake (CF – carb free)

Basal rate

Bolus

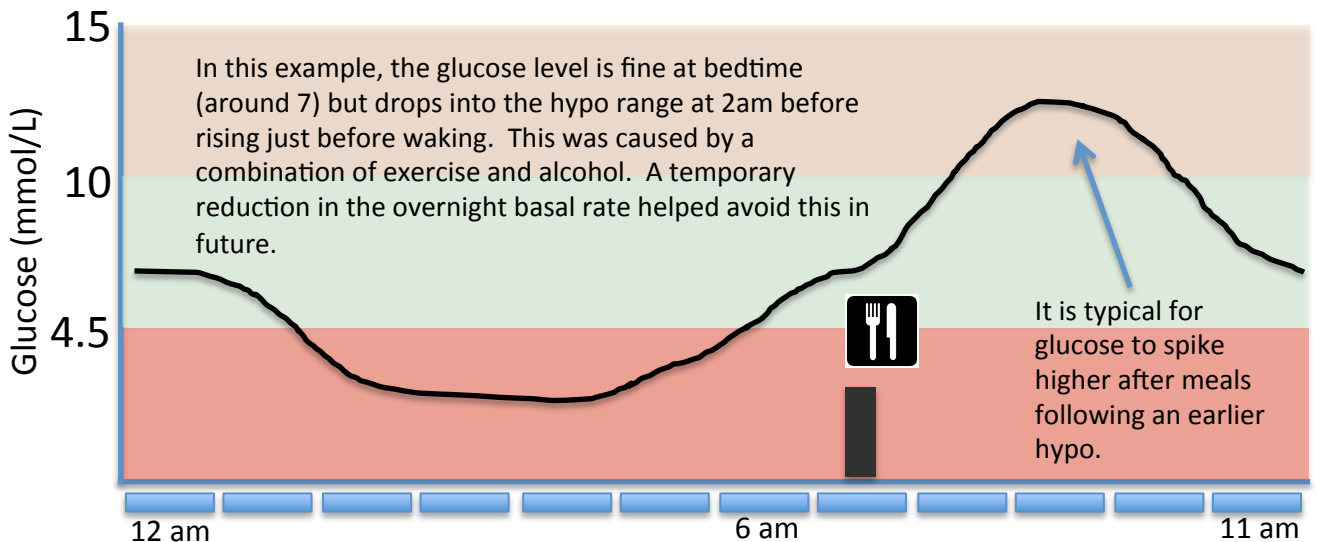
Above target

In target

Below target

1

Step 1: Avoiding overnight hypos



Headline

Hypos overnight are a problem for several reasons:

- They are harder to detect than hypos during the day.
- If they occur frequently they can affect your ability to detect hypos early.
- They tend to cause the glucose to rise in the morning and after breakfast.

You can't really exclude overnight hypos unless you have checked your blood glucose at 3am on a few occasions – your glucose level can be normal on waking, even if it was low earlier. We don't recommend you do this routinely, but it is certainly worth considering every now and then.

What causes overnight hypoglycaemia?

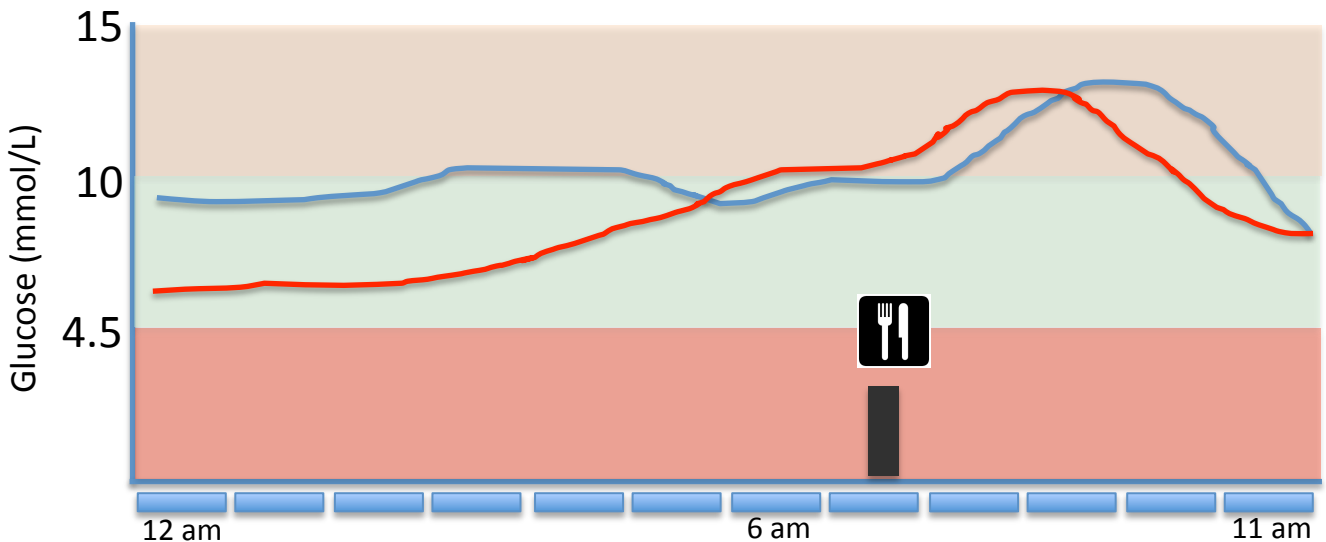
- Too high an overnight basal rate(s).
- Prolonged exercise the day before (without appropriate carbohydrate replacement or reduction in insulin dose).
- Drinking alcohol the night before (alcohol stops the liver making glucose – which normally maintains the blood glucose overnight).

How to solve this problem

- If you're going to bed with a normal glucose and it is consistently dropping overnight – you need a lower basal infusion rate(s) overnight (consider a 10% reduction in infusion rate). As an example, if your overnight basal rate was 1 unit per hour, this would mean a 0.1 reduction to 0.9 units per hour.
- After prolonged exercise you may need to adjust basal infusion rate(s) overnight (20 – 30%) using a temporary basal rate.
- Consider a reduced overnight basal rate(s) on evenings where significant amounts of alcohol are consumed (and ensure you have had a carbohydrate snack before bed) – temporary basal rate.

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Step 2: Getting the morning blood glucose on target



Headline

Starting the day with a high blood glucose makes getting things under control much more difficult than starting the day with an 'on target' glucose. If the first priority is avoiding hypoglycaemia, the second is certainly getting control of the morning glucose.

What causes high morning blood sugar levels?

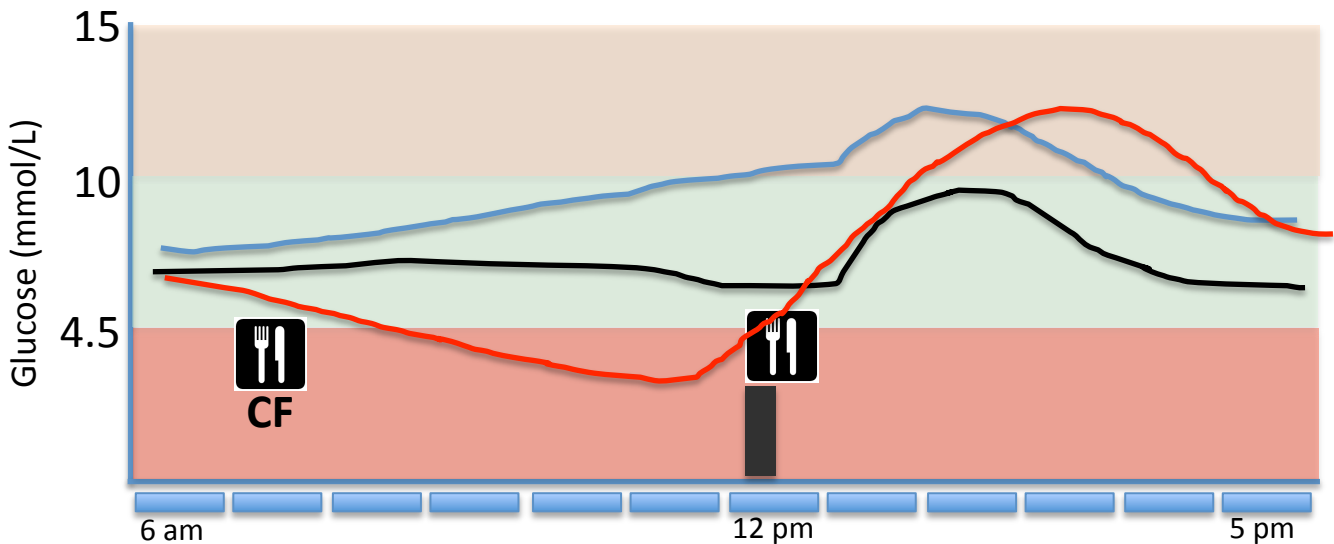
- The blue line in the figure above is an example of someone going to bed with a high glucose (around 10) and waking up with a similarly high glucose. In situations like this, it is worth looking at how effective the previous evening's tea time bolus dose had been. The overnight basal insulin is supposed to keep the glucose steady overnight and it appears to have done so (see step 4 [page 8] for more details on assessing the effectiveness of mealtime insulin doses).
- The red line is an example of not enough basal insulin. The glucose starts off fine at bedtime but rises progressively through the night. This may be because the basal insulin infusion rate is too low.
- The 'Dawn Phenomenon' is a situation where blood glucose levels rise significantly between 3am and waking. This affects some patients more than others and is caused by the early morning rise in hormones (cortisol and growth hormone) which make the body more resistant to the effects of insulin.

Solutions

- Firstly it is important to make sure that pre-bed glucose readings are generally OK.
- If it appears to be related to an inadequate basal rate overnight, this can be dealt with by increasing the overnight infusion rate (by 10 – 20%) .
- The Dawn Phenomenon can be dealt with by setting a higher basal rate to commence at around 3am (10% increase at this point).

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Step 3: Sorting out the basal infusion rates



Headline

As a 'rule of thumb', most people require around 40 – 50% of their insulin as basal and 50 – 60% bolus (with meals). If your basal insulin dose comprises a much bigger proportion of your total dose, it may be too high. This is important as excessive basal insulin can drive your appetite (weight gain) and also leave you open to hypos.

How can I tell if my background insulin dose is correct?

The best way to test this is by occasionally having carbohydrate free meals (or fasting), which means you do not have to take any bolus insulin at that time point. In the example above, the patient has taken a 'carb free' breakfast.

The black line shows what should happen if the basal insulin is 'doing its job' – the glucose more or less remains steady. The red line shows what would happen if someone has too high a basal rate – the glucose levels fall into the hypo range. The blue line shows what would happen if the basal rate is too low – the glucose level rises over the morning.

You can also perform carb free (or fasting) at lunch and tea time to see how effective the basal rates are across those periods. It is best not to do more than one in a single day!

What changes can be made?

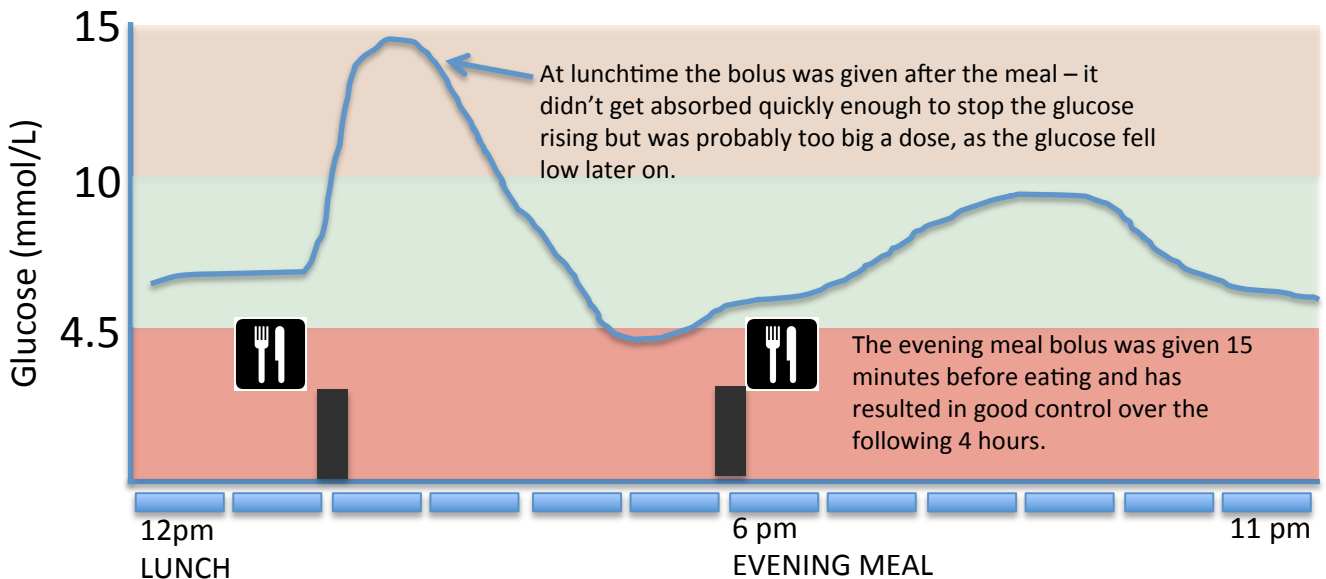
- If glucose is falling after carb free meals (or fasting) then this suggests a decrease in basal insulin rate across that period (around 10% adjustment).
- If glucose is rising after carb free meals (or fasting) then this suggests an increase in basal insulin rate across that period (around 10% adjustment).

Temporary basal rates

The pump offers the advantage of being able to set a temporary increase or decrease in the basal rate for a specified duration. This can be useful in the context of exercise, illness, stress and, in some women, in the pre-menstrual period. You can even set different basal patterns for work days and weekends to reflect difference in activity (which can have a significant effect on insulin requirement).

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Step 4: Matching the bolus dose with meals



Headline

The best way to match insulin doses with meals is to perform carbohydrate counting – adjusting your dose for what you eat and not adjusting what you eat to suit your insulin dose. If you're not doing carb counting, we would strongly recommend you get in touch with us to arrange some input from the specialist dietitians.

Matching the dose – what factors are important?

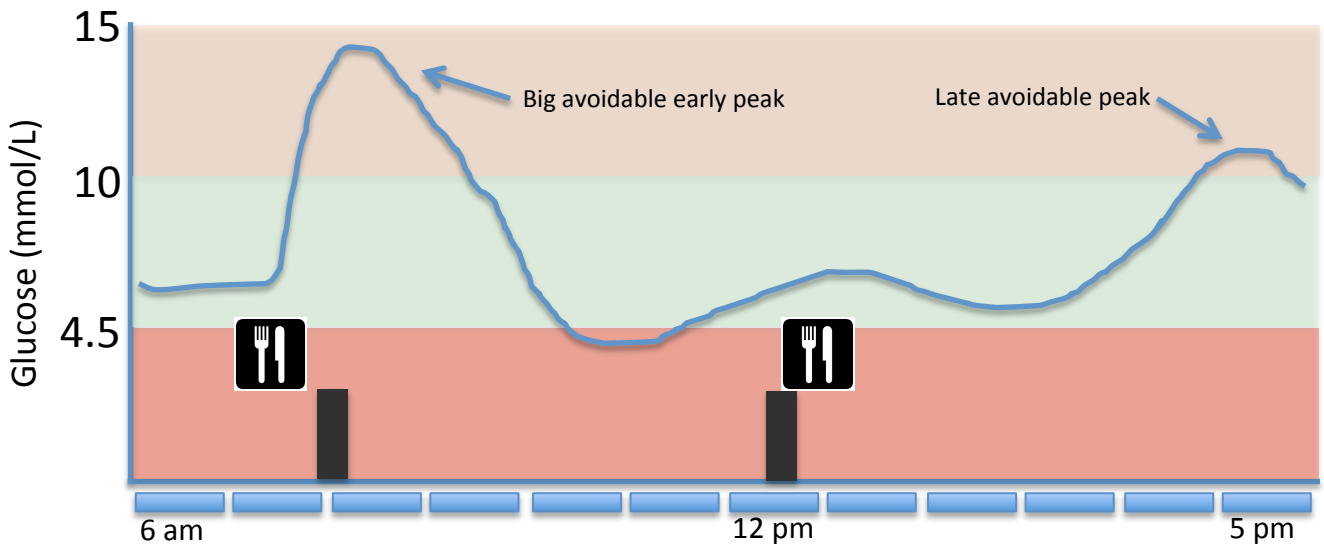
- Over time people gain experience in estimating the carb content of the foods they most commonly consume. The more you do it, the better you get. The mobile app (and book) 'Carbs and Cals' is a convenient reference to help with this.
- The required ratio of insulin to carbohydrate is different for each person and, even in the same person, can be different at breakfast (where sometimes more insulin is required) than with later meals. A rough guide to the expected insulin to carb ratio is provided in Appendix 2 (page 16). The ratio can also change over months and years – so it is worth assessing this periodically.
- Timing of bolus doses can be important and is discussed more in step 5.

Is my matching working?

- The first thing to do is make sure your basal insulin is appropriate (step 3) – once you're happy with this...
- Checking a glucose level before a meal, **two hours after eating** and before the next meal can provide very useful information:
 - If the two hour level is high (it should ideally be less than 10 and not rising much more than 2 compared to before the meal) this may mean your ratio needs to change to give more insulin. If dropping low at 2 hours – a reduction may be required. Change the ratio by 3 to 5 grams carbohydrate.
 - Example: if your ratio is 1:15 and glucose is too high after meals – change the ratio to 1:12.
 - If the two hour level is high but drops low at 4 to 5 hours- this may mean the timing of bolus insulin needs adjusted (i.e. to be taken further in advance of the meal).

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Step 5: Getting the timing right



Headline

Although insulins like Novorapid, Humalog and Apidra are 'rapid acting', they still take up to 30 minutes to be absorbed, even when given by pump. This means that carbohydrate based meals (sugars, bread, potatoes, pasta) can result in a big peak of glucose before the insulin has had an opportunity to start working. On the other hand, meals which contain a lot of fat (Pizzas, 'take-away' food etc.) can delay glucose being absorbed from the gut and may result in slower, prolonged appearance of glucose.

Working out the best timing

Looking at glucose results 2 hours after eating, and again prior to the next meal, provides good evidence of whether your bolus is working effectively. It is worth thinking about this for different meal types. In the example above, taking insulin **after** a carb heavy breakfast has caused a big early rise in glucose but giving a standard bolus **before** a fatty meal (with slowly absorbed carbohydrate – e.g. Mexican food) at lunch time has failed to match the later peak in glucose.

You can see, in the example above, that simply checking a glucose before lunch (which was quite low) may result in reducing the dose of breakfast insulin which would result in an even bigger glucose 'spike' after breakfast. Less insulin may be required but getting the timing (or bolus type) right is the critical thing here.

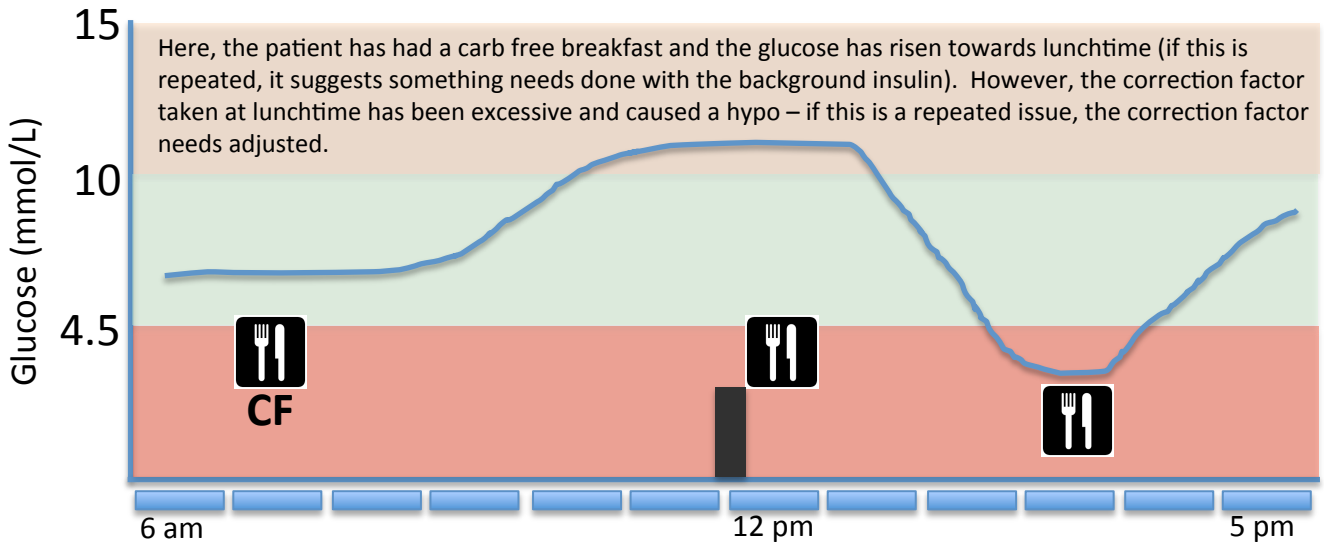
Similarly, just looking at the pre-evening meal glucose level (which was high) may cause you to increase future doses of insulin at lunch time, which would increase the risk of hypoglycaemia in the early afternoon with this type of food. Again, timing and not the amount of insulin is perhaps a bigger issue in this case.

Different types of bolus

Insulin pumps can give an immediate bolus, an extended bolus or a mixture of immediate and extended. Immediate bolus is the standard approach but some food types (where the absorption of glucose is delayed) may benefit from an extended bolus or combined immediate-extended bolus.

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Step 6: Getting the correction factor right (and not over-using it)



Headline

Correction factors (or insulin sensitivity) are an important tool in helping to manage the blood glucose level. One of the major benefits of regularly checking glucose levels is the ability to ‘correct down’ unexpected high readings at meal times. However if corrections appear to be the norm at particular times of day, it is worth considering what factors are contributing to the persistently high glucose readings and addressing them, rather than relying on corrections (e.g. wrong I:C ratio with preceding meal, problems with basal insulin etc.). Constant corrections can make it difficult to pick out underlying patterns and sometimes it can be useful to stop correcting for a spell to help work out what is causing the underlying problem.

Correction factors, like insulin:carbohydrate ratios, differ between individuals and can also be different at different times of day. Aiming to correct down to a glucose of 7 mmol/L is typical.

What is my correction factor?

A simple way to estimate your correction is:

$$\text{Correction factor} = 100 / (\text{total daily insulin dose})$$

So in someone taking roughly 25 units of bolus and 25 units of basal (total insulin = 50 units):

$$\text{Correction factor would be } 100 / 50 = 2$$

This means 1 unit would be expected to drop the blood glucose by 2 mmol/L.

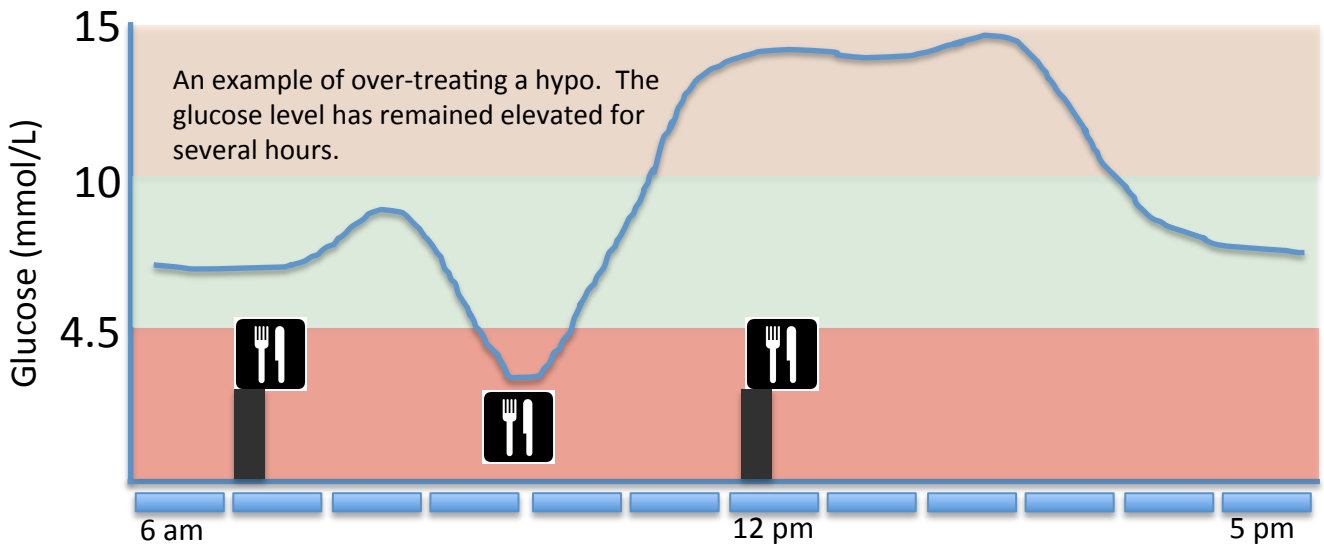
If at lunch time their blood glucose was 13 they would take 3 extra units on top of their calculated dose (those 3 units would be expected to drop the glucose by 6, therefore getting them to their target glucose of 7).

If correction factors start to become associated with subsequent hypos, then they should be increased (e.g. from 1 unit lowering 2 mmol/L to 1 unit lowering 2.5 mmol/L). If they do not seem to be getting the glucose down to target, they may need decreased (e.g. down to 1 unit lowering 1.5 mmol/L glucose).

Using the bolus wizard allows the pump to take into account ‘insulin on board’ / ‘active insulin’ and helps deliver a more appropriate correction dose.

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Step 7: Treating hypos appropriately



Headline

With regular monitoring and appropriate adjustment of insulin, episodes of hypoglycaemia (glucose less than 3.5 mmol/L) can be kept to a minimum. However, it is not unusual to experience a few episodes of ‘mild’ hypoglycaemia and the important thing is to be aware of the warning signs and treat them at the earliest possible opportunity.

If hypos are occurring at the same time each day on a regular basis, it is important to consider why and aim to prevent them – the earlier steps in this booklet should help reveal most of the common reasons.

What is the best way to treat hypoglycaemia?

The best way to immediately treat a hypo is to consume **15 – 20 grams of rapid acting carbohydrate**. If the hypo occurs less than an hour before your next meal, this may be all that is required. If it happens 1-2 hours before a meal then you may wish to take an additional **10 grams of longer acting carbohydrate** (e.g. bread) and if it is even longer until your next meal you may wish to consider **20 grams of longer acting carbohydrate**.

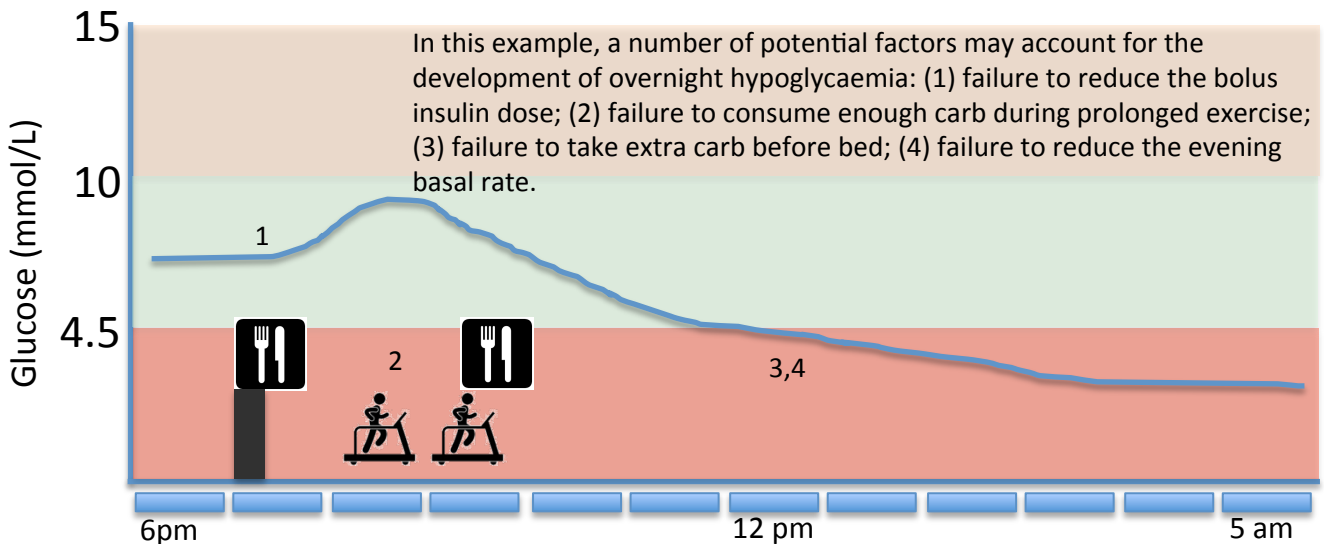
It is important to repeat the treatment if you do not feel better after 5 minutes. It is a good idea to recheck your glucose level after 15 minutes – if it is still low, repeat the treatment.

	15 grams carb	20 grams carb
Lucozade	100ml	133ml
Cola	150ml (mini-can)	200ml
Glucose tablets	~4 tablets	5 tablets
Dextrose tablets	5 tablets	~7 tablets

Over-treating hypos is not a good idea, as it can make managing your blood glucose very difficult in the following hours (like the example above). If you find your typical treatment of hypo tends to ‘overshoot’ you may wish to consider using a lower dose of carbohydrate – for safety, it is important to check blood glucose regularly following a hypo. After a hypo, another hypoglycaemic episode is more likely in the next 24 hours and it important to monitor carefully to avoid this.

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Step 8: Dealing with exercise



Headline

Exercise is hugely important – it has the potential to improve wellbeing (physical and mental) as well as providing long-term benefits in maintaining health. Unfortunately many people with diabetes will avoid exercise due to fear of hypoglycaemia. However, with the correct precautions, there is no reason to fear exercise and indeed there are many examples of elite athletes with type 1 diabetes. Getting dose adjustments and carb intake just right, tends to require some ‘trial and error’ and can vary a lot from person to person.

Preparation

- Ideally aim for a glucose between 5 – 10 mmol/L prior to exercise.
- If the activity is less than 45 minutes:
 - Take 20 – 30g of carb if glucose less than 7 mmol/L.
 - Take 10 – 20g of carb if glucose between 7 and 10 mmol/L.
 - If glucose between 10 to 13 mmol/L – no extra carb required.
 - If glucose greater than 13 mmol/L – consider postponing exercise.
- If exercise is prolonged (more than 4 hours) or intense (running / aerobic class) reduce bolus insulin before exercise by 30 – 50% (you will need to assess what is right for you).
- If you are making a temporary reduction in basal rate, it tends to be most effective if performed 1 – 2 hours before the onset of exercise.
- For exercise more than 4 hours, basal and bolus may need cut by up to 50%.

During

- Depending on the intensity and duration of the exercise, it is likely that extra carbohydrate will need to be consumed during the exercise (see appendix 3, page 17 for specific advice on extra carbs)

After

- A 20 – 30% reduction in night time basal rate may be required after exercise.
- Extra carbohydrate before bed may be required to help restore muscle glucose stores.

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Step 9: Periodically review your patterns (and share them)



Headline

We know that regular blood glucose checks are associated with better diabetes management (as demonstrated in the table below). The next step is to understand what influences your glucose levels and periodically look for patterns. We would recommend Medtronic pump users set up a CARELINK account. Other pump users should use Diasend Personal. These allow you to look over your glucose patterns and recognise problems (example images above). **Ideally it is worth reviewing this information for around 5 – 10 minutes each week.** You can also share this information with staff at the clinic, who will be very happy to offer advice. For information on CARELINK and DIASEND PERSONAL please visit our website:

www.edinburghdiabetes.com

Then go to 'RIE Diabetes' > 'Pump Patients'

Number of blood glucose tests per day	Average HbA1c % (old units)	Average HbA1c mmol/mol (new units)
0 to 2	8.6	71
3 to 4	8.0	64
5 to 6	7.6	60
7 to 9	7.4	57

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Step 10: Use **your** diabetes clinic to suit you

Headline

You manage your diabetes for over **5000** waking hours each year. We see you in clinic for perhaps 1 or 2 hours over that period. We don't want to wait for 6 months to hear about any problems you may be having – we want to know as soon as possible, to help put a plan in place to put you back in control. Over time, with regular blood glucose checks, review of patterns and putting changes in place, we are confident that most people can achieve good management of their diabetes. The aspiration of our clinic is to empower people to do this by themselves but also to be available for advice whenever it is required. Over time, this process should become more automatic: you control your diabetes – it doesn't control you.

We would urge you to contact us for advice whenever you like:

By email: **diabetesclinic.rie@nhslothian.scot.nhs.uk**
(ask us to review your Diasend/Carelink or look over scanned diaries)

By telephone (leave a message): 0131 242 1470 / 1471

Appendix 1: Carb free meals

Breakfast

- Fried/ poached/ boiled egg
- Fried/ poached/ boiled egg and bacon/ smoked salmon
- Fried/ poached/ boiled egg with avocado
- Avocado
- Cheese selection e.g. cheddar, brie, feta, mozzarella

Main Meals – moderate portions

- Omelette (without milk) – cheese and ham (or meat/ cheese/ vegetable of choice)
- Seasoned/smoked Fish (no breaded/ battered/ lightly coated varieties)
- Roast/grilled/baked/fried meat of choice e.g. gammon, chicken, beef, steak, lamb
- Chilli con Carne with meat/ vegetables of choice (without kidney beans or rice)
- Curry – Meat or vegetable (without rice)
- Stew/ Casserole (no flour/ potato)
- Homemade Beef/ Turkey/ Spiced lamb burger (no added breadcrumbs or bun)
- Cold meat/ fish salad
- Tofu

Accompaniments

- x1 tbsp mayo
- Olive oil/ extra virgin olive oil
- x1 tsp mustard
- x1 tbsp cider/red wine/malt vinegar
- Garlic/ Herb butter

Sides – (raw, boiled, steamed, fried)

- Salad leaves/ celery sticks/ broccoli/ cucumber/ mushrooms/ bamboo shoots/ asparagus/ sprouts/ cabbage/ cauliflower/ beans (no baked beans) / avocado / onions/ tomatoes.

Drinks

- Diet fizzy juice e.g. diet cola, diet orange, diet lemonade
- Mineral/ Tap water
- Carbonated water
- Some flavoured sparkling water (~ 0.5g CHO/250ml – always check labels)

Appendix 2: Insulin:carb ratio guide

Average daily insulin dose (background and quick acting)	Approx I:C ratio
8 – 11	1:50
12 – 14	1:40
15 – 18	1:30
19 – 21	1:25
22 – 27	1:20
28 – 35	1:15
36 – 45	1:12
46 – 55	1:10
56 – 65	1:8
66 – 80	1:6
81 – 120	1:5
> 120	1:4

Kilograms	Stones	Approx I:C ratio
<27	< 4.2	1:30
27 – 36	4.3 – 5.7	1:25
37 – 45	5.8 – 7.1	1:20
38 – 54	7.2 – 8.6	1:18
55 – 64	8.7 – 10	1:15
65 – 77	10.1 – 12.1	1:12
78 – 90	12.2 – 14.2	1:10
91 – 104	14.3 – 16.4	1:8
105 – 122	16.5 – 19.3	1:6
>122	>19.3	1:5

The table on the left uses total daily insulin dose to estimate insulin:carbohydrate ratio, whilst the table on the right uses weight to make the same estimate. **These are only guides** and assessment of response, as detailed in step 4 (page 8) is the best way to determine the appropriate I:C ratios for each meal time.

If your I:C ratio is not working (post meal glucose levels too high or too low) then consider changing the ratio by 3 to 5 grams.

Appendix 3: Carbohydrate intake during exercise

Pulse	% Max pulse	Borg scale	Description	Recommended carbs per hour
60		6	No exertion at all	
70		7	Extremely easy	
80		8		
90		9	Very easy	
100		10		
110	65%	11	Light exertion	0.5g/kg/hr
120		12		
130		13	Moderate exertion	1g/kg/hr
140	75%	14		
150		15	Exhausting	1.5g/kg/hr
160	85%	16		
170		17	Very exhausting	>2g/kg/hr
180	92%	18		
190		19	Extremely exhausting	
200	100%	20	Maximally exhausting	

This table offers suggestions for how much carbohydrate should be consumed during exercise, depending on how intensive it is. As a rough guide, if you are unable to talk to someone whilst exercising – you are likely to be at level 17 or above (i.e. requiring >2g/kg/hr).

Appendix 4: Getting the most out of your pump

Insulin pumps offer a number of benefits over conventional insulin injections but to get the most out of the pump it is important to be able to take advantage of all the pump's features. Please have a look over the following checklist. If there are features here you are not sure how to use, please get in touch with the clinic and we can arrange an education session:

Giving a bolus dose	
Cancelling a bolus dose	
Setting the missed bolus reminder	
Setting your basal rates	
Setting different basal patterns (e.g. work day / weekend)	
Setting a temporary basal rate	
Setting up the bolus wizard (bolus calculator)	
Using the bolus wizard (bolus calculator)	
Connecting your pump to the glucose meter (Medtronic pumps)	
Setting up and using CARELINK to review your results on your computer (Medtronic)	
Setting up and using DIASEND to review your results on your computer (All other pumps)	
Changing a set / Choosing a set	
Pump failure – what to do	
Sick day rules	

1

Avoiding overnight hypos

2

Getting the morning glucose on target

3

Sorting out the basal infusion rates

4

Matching bolus doses to meals

5

Getting the bolus timing right

6

Getting the correction factor right

7

Treating hypos appropriately

8

Dealing with exercise

9

Review your patterns

10

Use your diabetes clinic to suit you