

Blood Sugar Tests and Adjusting Insulin

A Guide for Patients & Carers

St Helens & Knowsley Teaching Hospitals NHS Trust
Specialist Diabetes Team
September 2020

Introduction

The aim of this guide is to help with 2 things:

- (1) How to understand blood sugar test results
- (2) How to use those test results to safely adjust insulin

What do you need to know, to use this guide

- (1) What insulins you use and when.
- (2) Your blood sugar test targets.

What insulins you use and when

Most adult insulin-users who have attended St Helens & Knowsley Teaching Hospitals NHS Trust Specialist Diabetes Service will be on one of the following 4 treatment plans:

- (a) A 'basal-bolus regimen' or 'MDI regimen' (they're the same). You take a once-daily longer-acting basal insulin (usually at bedtime) and a 'bolus' injection of fast-acting insulin 10-15 mins before each meal.
- (b) A twice-daily mixed insulin. You take an injection of premixed insulin 10-15 mins before breakfast and an injection of premixed insulin 10-15 mins before your evening meal.
- (c) Insulin-tablet combination therapy. Typically, you will take an injection of longer-acting basal insulin at bedtime plus one or more diabetes tablets during the day.
- (d) Insulin pump therapy. You use an insulin pump delivering a background or basal rate of insulin (this may vary at different times of the day) and you give yourself 'boluses' of insulin 10-15 minutes before meals. **Pump therapy is not dealt with in this document.**

There are many variations on these insulin regimens, but understanding blood sugar test results and adjusting your insulins are more or less the same. If you're on an unusual treatment plan and you are unsure – ask your doctor or nurse.

Let's look at some examples of insulin treatment plans (regimens):

Basal-bolus regimen

- (i) Insulin Toujeo (longer-acting basal insulin) 36
Insulin Apidra (fast-acting, bolus insulin) 12 + 14 + 18

This short-hand tells us that you take Insulin Toujeo, 36 units at bedtime and Insulin Apidra, 12 units before breakfast + 14 units before lunch + 18 units before evening meal.

Twice daily premixed Insulin

- (ii) Novomix 30 26 + 14

This is shorthand for Insulin Novomix 30, 26 units before breakfast and 14 units before the evening meal.

Insulin-tablet combination therapy

- (iii) Insulin Insuman Basal 66
Plus Metformin 1000 mg b.d. + Gliclazide 160 mg b.d.

This is shorthand for Insulin Insuman Basal, 66 units at bedtime in combination with Metformin tablets 1000 mg (= 1g) twice daily with breakfast & evening meal plus Gliclazide tablets 160 mg twice daily before breakfast and evening meal.

Blood sugar tests

This guide assumes that you already test your blood sugars. If you don't and you're taking insulin, ask your GP or nurse about blood sugar testing.

Single readings

Single readings are sometimes useful.

When is a single reading useful?

1. A single low reading (less than 4.0) - take immediate action to raise your blood sugar. This book will not discuss how you treat hypos (low blood sugars) – you should have been taught about hypos and how to treat them and you can find extra information elsewhere – for example, on the Diabetes UK website or the St Helens & Knowsley Teaching Hospitals NHS Trust diabetes internet page (see patient information book). If in doubt, ask your GP or nurse.

2. A single very high reading (for example 24.2 mmol/l) – you should check for blood ketones and ask yourself – do I feel well or do I feel ill? If you feel fine and your ketones are normal, you need take no further action except checking your sugars more frequently for a while. If you feel ill or your ketones are raised, you should seek urgent medical help.

3. A single reading is also useful when it is associated with driving so that you can ensure that you comply with DVLA guidance. There may be other similar situations when knowing your blood sugar is ok is reassuring, for example before, during or after exercise or when operating machinery.

Multiple readings

So single readings can be useful, but usually we look at **multiple** readings to understand what’s going on with our diabetes.

Consider a set of readings:	Before Breakfast	Before Lunch	Before Tea	Before Bed
Day 1	6.1	11.3	5.5	9.7

What does this tell us?

The answer is – not a lot! Everyone who has diabetes knows that blood sugar readings vary and making sense of a single reading is tricky.

Consider ‘Bob’

- Bob has type 1 diabetes. Bob is very meticulous! Bob gets up every morning at 07.19. Bob takes his insulin 15 minutes and 0 seconds before breakfast. Bob has 1.73 Weetabix, 71 ml of milk, a standard cup of tea. Bob walks 119 yards to the Newsagents and buys his morning paper and then he checks his blood sugar:
 - On Monday, Bob’s blood sugar is 7.1
 - On Tuesday, Bob’s blood sugar is 14.3

- How can this be? The implication of the story is that everything that affects blood sugar is the same on Monday and Tuesday and therefore the blood sugar readings should be the same. But they never are! Why not?

The answer is because we haven’t really controlled everything that affects blood sugar. In reality, our mood affects our blood sugar, the weather can affect our blood sugar, for women, their period can affect their blood sugar. Day to day, we might absorb slightly more or less of our meal and we might absorb slightly more or less of our insulin..... and when you add all of this together, it results in a blood sugar on Monday of 7.1 and a blood sugar on Tuesday of 14.3.

This is not a silly story. It’s really important! Blood sugars vary – don’t waste hours of your life trying to figure out what was different between Monday and Tuesday – just accept it!

What does this tell us about interpreting blood sugar tests?

- Whilst single readings can be useful (see above), usually we need multiple readings to know what’s going on.

If we have multiple readings, we see past the day-to-day variations:

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Day 1	6.1	11.3	5.5	9.7
Day 2	11.5	5.6	6.1	9.7
Day 3	12.1	4.7	6.1	9.1
Day 4	9.9	6.6	5.9	8.3
Day 7	13.2	6.8	9.1	6.5
Day 9	8.4	6.1	4.1	6.9
Day 10	7.1	5.9	3.8	4.1
Day 13	5.4	12.1	12.4	10.1
Day 14	4.8	4.6	5.6	6.9
Day 15	11.1	8.4	6.4	7.6

We need to translate the table of numbers into a **MESSAGE – what are the numbers telling us?** To answer this question, we must first know what we’re aiming for.

Targets for blood sugar readings vary – they are **INDIVIDUAL**. Let’s return to Bob. Bob has a target HbA1c (average blood sugar test) of 58 mmol/mol (7.5% in old units) and his target blood sugars that he’s agreed with his nurse or doctor are:

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0

Let’s **CONVERT** Bob’s readings into a **MESSAGE**. Let’s use a highlighter pen to do this. We’re going to colour any sugar that is in target (see above) **GREEN**, we’re going to colour any sugar that is below target **RED**, and we’re going to colour any sugar that is above target **AMBER**.

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Day 1	6.1	11.3	5.5	9.7
Day 2	11.5	5.6	6.1	9.7
Day 3	12.1	4.7	6.1	9.1
Day 4	9.9	6.6	5.9	8.3
Day 7	13.2	6.8	9.1	6.5
Day 9	8.4	6.1	4.1	6.9
Day 10	7.1	5.9	3.8	4.1
Day 13	5.4	12.1	12.4	10.1
Day 14	4.8	4.6	5.6	6.9
Day 15	11.1	8.4	6.4	7.6

Now let's transfer the colours into the MESSAGE:

Green = OK

Amber = above target

Red = below target

	Before Breakfast	Before Lunch	Before Tea	Before Bed
	6.1	11.3	5.5	9.7
Day 1	11.5	5.6	6.1	9.7
Day 2	12.1	4.7	6.1	9.1
Day 3	9.9	6.6	5.9	8.3
Day 4	13.2	6.8	9.1	6.5
Day 7	8.4	6.1	4.1	6.9
Day 9	7.1	5.9	3.8	4.1
Day 10	5.4	12.1	12.4	10.1
Day 13	4.8	4.6	5.6	6.9
Day 14	11.1	8.4	6.4	7.6
Overall colour	Mostly amber	Mostly green	Mostly green	Mostly green
Overall MESSAGE	Above target	OK	OK	OK

Once we've got the overall message, we can forget/ignore the numbers. All we are now interested in is the final row:

Overall MESSAGE	Above target	OK	OK	OK
------------------------	--------------	----	----	----

This will now guide insulin dose adjustment (more about that a bit later).

Which insulin do we adjust?

If we're going to use blood sugar test results to adjust insulin doses, we need to know which insulin to adjust when a particular blood sugar column is out of target.

Let's go back to our different insulin treatment plans (regimens):

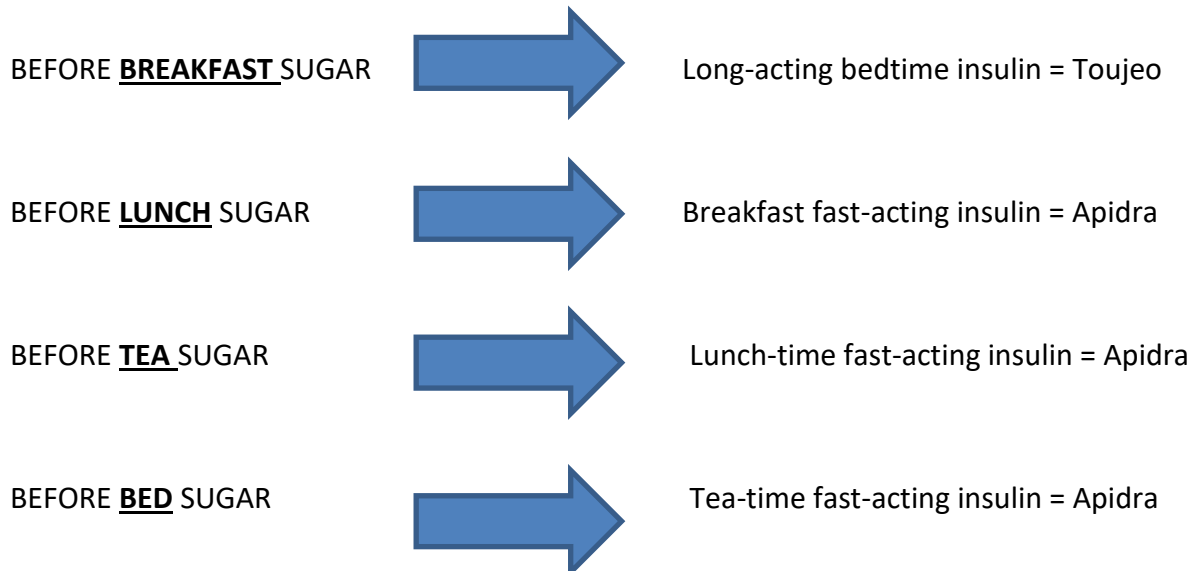
1. **Basal-bolus regimen.** You will be taking a once-daily longer-acting basal insulin (usually at bedtime) and a 'bolus' injection of fast-acting insulin 10-15 mins before each meal.

Insulin Toujeo (longer-acting basal insulin)

36

Insulin Apidra (fast-acting, bolus insulin)

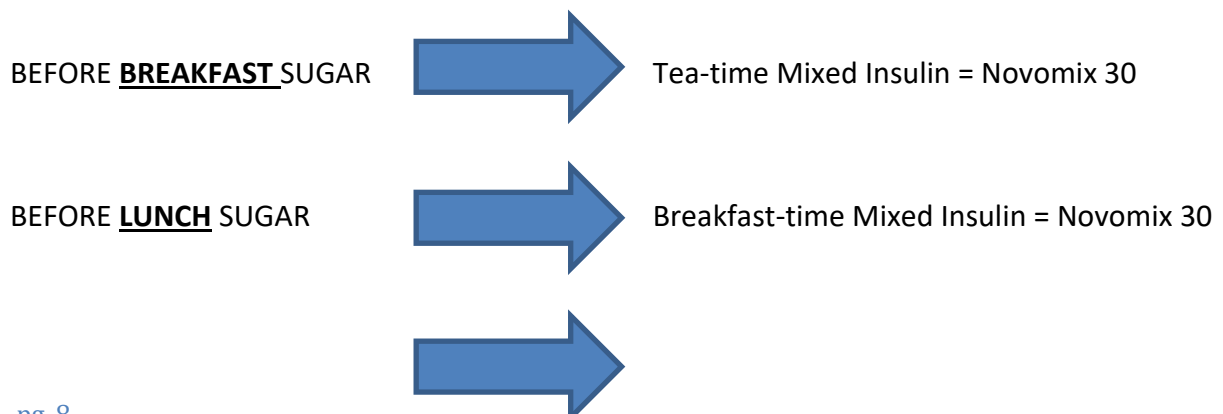
12 + 14 + 18



2. **Twice-daily mixed insulin.** You take an injection of premixed insulin 10-15 mins before breakfast and an injection of premixed insulin 10-15 mins before your evening meal.

Novomix 30

26 + 14



BEFORE TEA SUGAR

Breakfast-time Mixed Insulin = Novomix 30

BEFORE BED SUGAR



Tea-time Mixed Insulin = Novomix 30

Insulin-tablet combination therapy

- (i) Insulin-tablet combination therapy. Typically, you will take an injection of longer-acting basal insulin at bedtime and one or more diabetes tablets during the day.

Insulin Lantus 40
Plus Metformin 500 mg t.d.s.

BEFORE BREAKFAST SUGAR



Long-acting bedtime insulin = Lantus

In this regimen, the other sugars (before lunch, tea and bed) reflect the effect of the METFORMIN tablets.

By how much do we adjust each insulin dose?

Generally we adjust the dose by 10-20%.

For example:

- Pre-breakfast sugars too high → Increase Toujeo by 10% from 40 units to 44 units
- Pre-breakfast sugars too high → Increase Lantus by 20% from 20 units to 24 units
- Pre-breakfast sugars too high → Increase Lantus by 10% from 100 units to 110 units
- Pre-lunch sugars too high → Increase breakfast Apidra by 20% from 10 to 12 units

Putting it all together: worked examples

Danielle

Danielle has type 1 diabetes, treated with a basal-bolus regimen:

Toujeo

24

Apidra

8 + 8 + 8

Her agreed target HbA1c is 58 and her agreed target blood sugars are:

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0

Always start by looking at the before breakfast column

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0
Day 1	4.1			
Day 2	16.3			
Day 3	12.1			
Day 4	8.8			
Day 7	5.5			
Day 9	8.3			
Day 10	11.1			
Day 13	5.5			
Day 14	16.0			
MESSAGE	TOO HIGH			

ACTION: Danielle INCREASES her bedtime longer-acting insulin Toujeo from 24 to 28 and undertakes further monitoring for another 7-10 days.

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0
Day 1	6.2			
Day 2	5.5			
Day 3	12.1			
Day 4	9.4			
Day 7	5.8			
Day 9	7.1			
Day 10	4.3			
Day 13	7.2			
Day 14	5.9			
MESSAGE	TOO HIGH			

Much improved, but still overall just a little bit too high. **ACTION:** Danielle INCREASES her bedtime longer-acting insulin Toujeo from 28 to 30 and continues monitoring again.

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0
Day 1	6.4			
Day 2	5.5			
Day 3	5.9			
Day 4	7.1			
Day 7	5.1			
Day 9	3.4			
Day 10	5.6			
Day 13	6.8			
Day 14	6.1			
MESSAGE	OK			

Having sorted her pre-breakfast sugars, Danielle goes on and looks at her pre-lunch sugars.

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0
Day 1	6.4	4.8		
Day 2	5.5	4.8		
Day 3	5.9	5.5		
Day 4	7.1	6.9		
Day 7	5.1	7.8		
Day 9	3.4	4.4		
Day 10	5.6	5.9		
Day 13	6.8	5.2		
Day 14	6.1	8.1		
MESSAGE	OK	OK		

They're ok, so she looks at her pre-tea sugars.

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0
Day 1	6.4	4.8	3.9	
Day 2	5.5	4.8	3.6	
Day 3	5.9	5.5	2.8	
Day 4	7.1	6.9	16.1	
Day 7	5.1	7.8	5.5	
Day 9	3.4	4.4	6.1	
Day 10	5.6	5.9	4.2	
Day 13	6.8	5.2	4.0	
Day 14	6.1	8.1	2.8	
MESSAGE	OK	OK	TOO LOW	

ACTION: Danielle reduces her lunchtime fast-acting insulin Apidra from 8 to 6.

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0
Day 1	6.4	4.8	5.5	
Day 2	5.5	4.8	5.6	
Day 3	5.9	5.5	6.6	
Day 4	7.1	6.9	4.8	
Day 7	5.1	7.8	4.0	
Day 9	3.4	4.4	3.9	
Day 10	5.6	5.9	5.1	
Day 13	6.8	5.2	7.1	
Day 14	6.1	8.1	6.6	
MESSAGE	OK	OK	OK	

This sorts her pre-tea sugars, so finally she looks at her pre-bed sugars.

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0
Day 1	6.4	4.8	5.5	12.0
Day 2	5.5	4.8	5.6	11.1
Day 3	5.9	5.5	6.6	9.9
Day 4	7.1	6.9	4.8	7.4
Day 7	5.1	7.8	4.0	6.1
Day 9	3.4	4.4	3.9	5.5
Day 10	5.6	5.9	5.1	6.9
Day 13	6.8	5.2	7.1	8.9
Day 14	6.1	8.1	6.6	10.0
MESSAGE	OK	OK	OK	OK

Danielle’s sugars are now fine and 3 months later her HbA1c (average blood sugar test) is 52, reducing her risk of long-term complications (eye damage, kidney damage and nerve damage) – and she feels better!

Not everyone is the same!

Fred

Fred is 69, he has had type 1 diabetes for 40 years. He has had a heart attack and suffers with angina; he is also a bit unsteady on his feet after a stroke and his memory isn’t perfect.

Fred has switched from a basal-bolus regimen to a twice-daily mix because he finds it easier to manage:

Novomix 30 36 + 18

In view of his heart disease, poor mobility and poor memory, Fred, his carer and his doctor have agreed a target HbA1c of 69 and blood sugar targets of:

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	6.0 – 10.0	6.0 – 10.0	6.0 – 10.0	6.0 – 12.0

His monitoring results are as follows:

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	6.0 – 10.0	6.0 – 10.0	6.0 – 10.0	6.0 – 12.0
Day 1	12.3	5.4	5.9	11.1
Day 2	9.9	4.1	5.8	11.0
Day 3	8.5	4.4	6.1	12.0
Day 4	9.5	5.0	4.4	10.5
Day 7	10.0	6.8	7.9	14.1
Day 9	9.1	3.4	10.5	6.6
Day 10	8.7	4.1	5.4	9.5
Day 13	5.5	5.2	5.9	7.8
Day 14	9.7	3.8	3.3	9.9
MESSAGE	OK	TOO LOW	TOO LOW	OK

ACTION: Fred and his wife agree that he needs to adjust his Novomix 30 doses: breakfast time dose needs to be reduced, but his tea-time dose is OK:

Novomix 30 30 + 18

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	6.0 – 10.0	6.0 – 10.0	6.0 – 10.0	6.0 – 12.0
Day 1	6.8	6.6	7.7	11.1
Day 2	7.9	6.7	7.9	11.0
Day 3	11.1	5.9	8.4	10.3
Day 4	9.8	8.8	8.9	9.8
Day 7	9.6	9.1	11.1	8.9
Day 9	9.3	9.3	5.4	9.5
Day 10	7.5	8.9	6.6	8.9
Day 13	6.9	6.2	8.8	9.1
Day 14	7.8	7.4	9.4	6.1
MESSAGE	OK	OK	OK	OK

Fred and his wife are now happy with his sugars.

Joan

Joan is 56 and has type 2 diabetes. Previously, she managed with diet and tablets but for the past 12 months she's been using insulin-tablet combination therapy:

Insuman Basal

32

Metformin 850 mg t.d.s. (t.d.s. = 3 x daily) + Gliclazide 160 mg b.d. (b.d. = twice daily)

Target HbA1c is 58 and target monitoring is:

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0

It is, of course, the pre-breakfast sugars that guide the Insuman Basal dose

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0
Day 1	8.9			
Day 2	11.1			
Day 3	12.4			
Day 4	4.9			
Day 7	9.9			
Day 9	7.9			
Day 10	12.1			
Day 13	14.0			
Day 14	12.8			
MESSAGE	TOO HIGH			

ACTION: Joan increases the dose of her Insuman Basal to 38

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0
Day 1	6.9			
Day 2	7.5			
Day 3	7.2			
Day 4	6.6			
Day 7	7.1			
Day 9	9.9			
Day 10	5.6			
Day 13	12.1			
Day 14	7.7			
MESSAGE	TOO HIGH			

ACTION: Better, but still too high, so she further increases her Insuman Basal to 44 units.

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0
Day 1	6.1			
Day 2	6.6			
Day 3	5.9			
Day 4	7.1			
Day 7	5.5			
Day 9	6.9			
Day 10	5.1			
Day 13	5.5			
Day 14	6.8			
MESSAGE	OK			

When Joan checks sugars throughout the rest of the day, however, they're too high:

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Target	5.0 – 7.0	4.0 – 7.0	4.0 – 7.0	6.0 – 10.0
Day 1	6.1	8.8	12.3	12.4
Day 2	6.6	9.9	12.1	13.6
Day 3	5.9	9.1	11.1	10.3
Day 4	7.1	9.7	10.9	7.7
Day 7	5.5	10.1	7.9	8.9
Day 9	6.9	8.4	9.1	10.1
Day 10	5.1	5.6	8.5	14.2
Day 13	5.5	6.9	7.1	16.1
Day 14	6.8	11.0	6.6	12.5
MESSAGE	OK	TOO HIGH	TOO HIGH	TOO HIGH

This shows that the insulin dose is OK, but the regimen is not right for Joan – she needs a change of treatment plan, probably to a twice-daily insulin mix.

What happens when the message isn't clear?

Sometimes we have a column of 10 readings and 5 are high and 5 are ok. What do we do? Continue monitoring and it will typically become clear with more readings whether overall they're too high or ok.

What must I do next?

1. Know what insulins you use, when you use them and what doses you use.
2. Know your target HbA1c and target blood sugars.
3. Use the notes above to understand which blood sugars are affected by which insulin.
4. Test your sugars and record the results in a table as above (there is a blank table below that you can copy and use repeatedly).
5. Start with pre-breakfast sugars, then once you've sorted them, move on to pre-lunch sugars, then move on to pre-tea sugars and then finally pre-bed sugars. Deal with one column at a time – don't adjust multiple insulins at the same time.
6. Once you have 6-10 readings in the relevant column, compare them against your personal target and use a colour highlighter to decide whether they are largely OK, too high or too low.
7. Adjust the relevant insulin by increasing or decreasing it by about 10-20%.
8. Repeat the monitoring until you have a further 6-10 readings.
9. Keep repeating until most of your sugars are where you want them to be.

Appendix 1: My goals, my results and what I changed (copy as many times as you need to)

My insulin regimen is:

My current HbA1c is:

The HbA1c I want to achieve is:

My target blood sugars are:

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Personal Target				

My insulin that affects each blood sugar is (write the name and dose of the insulin in the box):

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Relevant Insulin				

My monitoring results are:

	Before Breakfast	Before Lunch	Before Tea	Before Bed
Personal Target				
Write date below	Write blood result	Write blood result	Write blood result	Write blood result
MESSAGE				

The action I took was:

Notes

Notes