t·r·e·n·d™ DIABETES

For Healthcare Professionals:

MONITORING IN ADULT DIABETES: GLUCOSE AND KETONES

CONTENTS

ABOUT THIS GUIDANCE

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About Trend Diabetes

TREND-UK was a working group of diabetes nurses with different skills and backgrounds, set up in 2009 in response to a request for a collective voice that represented all diabetes nursing groups. The original founding co-chairs of TREND-UK were experienced Nurse Consultants, working in a variety of settings and who were closely involved with other organisations representing nurses and other healthcare professionals working in diabetes.

This original group has now evolved into Trend Diabetes to reflect their work with other countries as well as the UK. Trend Diabetes produces a number of resources for healthcare professionals and people living with diabetes. These are available at www.trend-uk.org. Access to these resources is free of charge to anyone registering as a member of Trend Diabetes.

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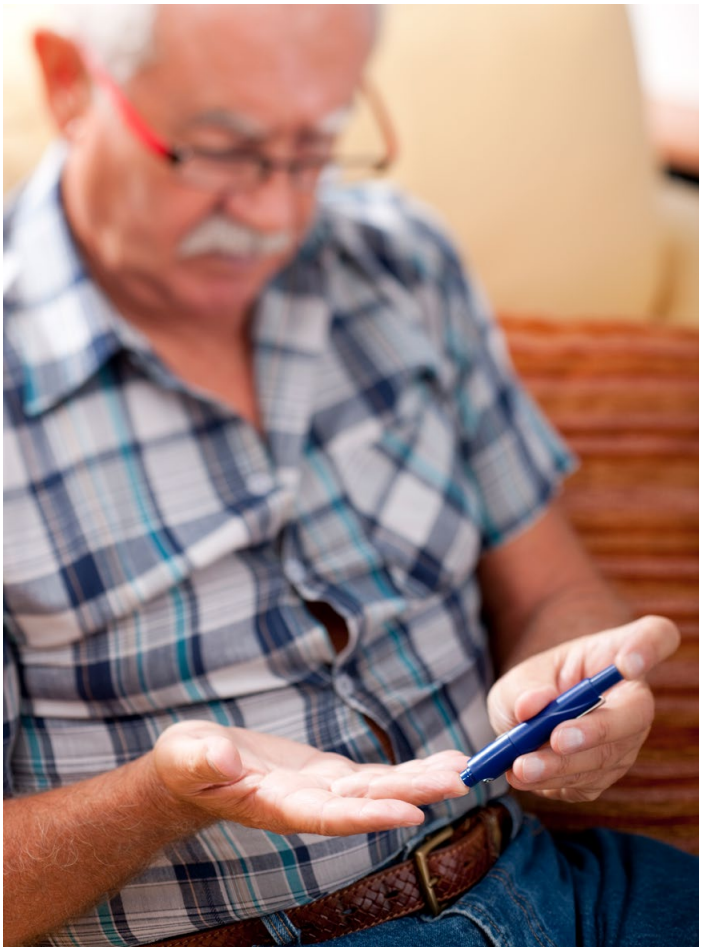
INTRODUCTION

Individuals living with diabetes resident in the United Kingdom are monitored by the National Health Service for a variety of reasons.

These include:

- To encourage access of early interventions to promote a long and healthy life and reduce the risk of diabetes complications
- To identify those at higher risk of developing other health problems and offer them the opportunity to make informed choices (NHS England, 2020)
- To facilitate, where possible, a good quality of life
- To prevent clinical inertia.



The diabetes annual review is most often used for monitoring health and well being but the percentage of people with diabetes receiving all their health checks is low, with 1 in 5 people with type 1 diabetes and 2 in 5 with type 2 diabetes achieving clinical targets for blood glucose, blood pressure and lipids (Diabetes UK, 2018). Educational opportunities and the maximising of diabetes therapies are important parts of this process.

Where monitoring is undertaken, it is important that the tests used are appropriate and accurate and that the healthcare professional (HCP) recognises what the results indicate and which other factors may need to be considered.

This document provides information on common tests used in glycaemic and ketone monitoring - these can signpost to where urgent action is needed to prevent ill health.

There are a variety of methods used to monitor the impact of therapies, lifestyle choices, co-morbidities, and inter-current illness on glycaemic control. These include:

- HbA1c
- Blood glucose monitoring (capillary blood)
- Continual glucose monitoring (interstitial fluid)
- Flash glucose monitoring (interstitial fluid).

HbA1c (GLYCATED HAEMOGLOBIN)

The HbA1c (glycated haemoglobin) reflects the exposure to prevailing blood glucose levels during the lifespan of red blood cells (approximately 120 days, but 50% of the value reflects the last 30 days) (WHO, 2011).

HbA1c targets for people already diagnosed with type 2 diabetes:

- Each person should discuss and agree their individual HbA1c target with their healthcare professional.
- HbA1c should be measured at least every 6-12 months but not more frequently than every two months.
- The recommended targets for people with type 2 diabetes are:
  - An HbA1c level of 48 mmol/mol, to minimise the risk of long-term vascular complications at diagnosis (type 2 diabetes) in those not taking a sulphonylurea or insulin.
  - If the individual is taking a medication associated with hypoglycaemia, the target HbA1c is 53 mmol/l.
  - If the HbA1c increases to 58 mmol/mol in type 2 diabetes, NICE (2015a) advise adding in additional therapy and then aiming for 53 mmol/mol.

⚠ **People who are frail and/or elderly or those with multiple comorbidities will require different glycaemic targets to ensure safety, according to the consensus recommendations (Strain et al., 2018):**

- **In people with diabetes and mild-moderate frailty, the HbA1c recommended target is 53-64 mmol/mol**
- **In people with diabetes and severe frailty, the recommended target is 59-69 mmol/mol (Strain et al., 2018).**

There are other factors which influence a decision for a specific HbA1c target; Table 1 offers a simple guide for HCPs to assess how stringent the HbA1c target needs to be.

Table 1: Approach to individualised glycaemic targets (Amended from American Diabetes Association, 2020).

Patient/Disease Features	More Stringent ❮ HbA1 7% (53mmol/mol) ❯ Less Stringent	
Risks potentially associated with hypoglycaemia and other drug-related adverse effects		Usually not modifiable
Disease duration		
Life expectancy		
Important comorbidities		
Established vascular complications		
Patient preference		Potentially modifiable
Resources and support system		

Psychological impact of glucose testing

As many as 67% of people living with diabetes report monitoring their blood glucose levels less frequently than is desirable for good health (Chadwick, 2014). The main reasons cited are:

- Discomfort or pain
- Dislike, fear or phobia of needles/sharps
- Inconvenience of testing
- Prioritising other life tasks and responsibilities
- Embarrassment
- Wanting to avoid reminders of diabetes.

Less invasive forms of monitoring such as CGM and flash glucose monitoring may overcome some of these factors. Barriers to glucose testing should be explored in the consultation with the healthcare professional. Whilst true needle phobia is rare, if present it will complicate self-management (Diabetes UK, 2019) and referral for psychological support is recommended (NICE, 2015a and 2015b). Psychological interventions based on cognitive behavioural therapy can assist the person to understand their thoughts and feelings about monitoring and to develop strategies to overcome their difficulties.

BLOOD GLUCOSE MONITORING

The importance of blood glucose (BG) control in reducing the risk of complications in people with type 1 or type 2 diabetes is well established (DCCT, 1993; DCCT/EDIC, 2005; UKPDS [UK Prospective Diabetes Study], 1998; Holman et al., 2008; Stratton et al., 2000). Both HbA1c and daily blood glucose variability influence this risk (Ceriello and Kilpatrick, 2013). The use of self-monitoring of blood glucose (SMBG) to facilitate the achievement of evidence-based blood glucose targets has increasingly been incorporated into routine management for many people with diabetes. Indeed, SMBG was described as possibly the most important advance in managing diabetes since the discovery of insulin (Tonyushkina and Nichols, 2009).

Cost of capillary blood glucose (BG) monitoring in the UK

Over 40 different types of blood glucose meters are available in the UK. The meters can be provided free of charge to people with diabetes through diabetes teams and practices, and the strips used with them are available on prescription. The cost of testing strips in 2019 was estimated to be £177 million (NHS Digital, 2019). Despite the financial constraints the NHS faces, it also has requirements to maintain quality, to afford newer, higher-cost treatments, to meet public expectations and to increase capacity to deliver healthcare services to all who need them. This has led to a consideration of how and where precious healthcare resources are used. Quality, Innovation, Productivity and Prevention (QIPP) recommended reviewing the routine prescribing of BG testing strips for people with type 2 diabetes who do not use insulin a number of years ago. They suggested this as an area where considerable financial savings could potentially be made for the NHS. This continues to be reviewed by local medicine management groups, who will recommend which meters should be used. In people with type 2 diabetes, many Clinical Commissioning Groups (CCGs) advise that:

- Prescribers in primary care should not initiate blood glucose testing strips that cost >£10 per 50 strips for any new patient.
- Support should be given to prescribers in de-prescribing blood glucose testing strips that cost >£10 per 50 strips and, where appropriate, ensure the availability of relevant services to facilitate this change.
- Blood glucose testing strips should not be included in the repeat prescribing list – they should be requested as and when needed.

In addition, people who blood glucose test should know how to alter their medication if readings are out of range.

The intention of the CCG recommendations is not that people with diabetes be prevented from blood glucose testing; it is instead intended to encourage prescribers to consider more cost-efficient alternatives.

Some existing blood glucose meters have the ability to test capillary blood glucose or blood glucose and blood ketones.

There are new technologies in this field, for example a meter is now available that can also help with basal insulin adjustment in people with type 2 diabetes who use insulin glargine.

Another development is a meter that tests blood glucose and blood ketones and can also link with an app. This can be used in type 1 diabetes to help with carbohydrate counting and insulin adjustment.

These recommendations do not include other agents that carry a risk of hypoglycaemia.

Table 2: The advantages and disadvantages of self-monitoring of capillary blood glucose.

Advantages
It enables the detection of hypoglycaemia and hyperglycaemia and can facilitate appropriate dietary and medication changes.
It informs people with diabetes and healthcare professionals when treatment changes are required to reduce the risk of short- and long-term complications.
It facilitates diabetes education and management, enabling individuals to self-manage their diabetes.
It informs the management of intercurrent illness and stress in order to reduce risk of acute metabolic decompensation (diabetic ketoacidosis and hyperosmolar hyperglycaemic state) and to avoid unplanned admission to hospital.
It can help motivate people toward healthier behaviour (Klonoff, 2007).
Disadvantages
SMBG is an invasive technique and some individuals find finger pricking painful and uncomfortable.
Testing can be inconvenient. People who regularly test have to carry supplies and ensure they can dispose of sharps safely.
Testing is costly, particularly if the results do not facilitate treatment changes.
The finding of a high capillary glucose result may cause anxiety and contribute to a negative experience of diabetes and its management.
Some people find the requirement to monitor regularly oppressive and a constant reminder of their condition (O'Kane and Pickup, 2009).

Quality standards for blood glucose meters

All BG testing devices have to meet the current ISO standards. ISO (International Organization for Standardization) 15197:2013 (E) describes the requirements for blood glucose monitoring systems using capillary blood (ISO, 2013). Originally developed in 2003, the standards were revised to be more stringent and were published in 2013. All capillary blood glucose monitoring systems had to have met the 2013 ISO standards (not the 2003 standards) by 2016.

Haematocrit affects the fluid content of blood (where the glucose is carried). Abnormalities of haematocrit can result in erroneous blood glucose results. High haematocrit (common in chronic respiratory conditions, high triglycerides, shock or dehydration) can give falsely lower BG readings (less fluid in the blood sample volume), whereas conditions with low haematocrit (e.g. pregnancy) give falsely higher BG results (Tonyushkina and Nichols, 2009).

Although the ISO standards are important, the skill of the user, not the meter, is the most significant source of BG errors, accounting for 91–97% of overall inaccuracies.

⚠ Quality assurance (both internal and external) for point-of-care testing by HCPs is mandatory (HMT, 2013).

Driving and blood glucose monitoring

Other organisations also have specific recommendations for people living with diabetes. The Driving and Vehicle and Licensing Authority (DVLA) emphasises the responsibilities of drivers when managing their diabetes. This is shown in Table 3.

Table 3: Driving and blood glucose monitoring.

Who should monitor?
✓ Group 1 drivers who take insulin or sulphonylureas (SUs).
✓ All insulin users must inform the DVLA, as this is mandatory.
✓ Group 2 drivers must advise the DVLA of any diabetes medications taken.
✓ People on SUs should test at times relevant to driving, to enable detection of hypoglycaemia.
✓ Blood glucose should be tested at least 2 hours before driving and every 2 hours on a long journey.
✓ The reading must be >5 mmol/L to drive.
✓ Advise people on an SU or insulin to carry fast-acting carbohydrate and a starchy snack (DVLA, 2020).

Getting the most out of capillary blood glucose monitoring

People with diabetes, HCPs, and professional carers using BG meters should know the individual BG targets and understand what action is required if the result is outside of target range (i.e. the detection and correction of hypoglycaemia and hyperglycaemia).

Other issues to consider are shown in Table 4.

Table 4: Getting the most out of capillary blood glucose monitoring

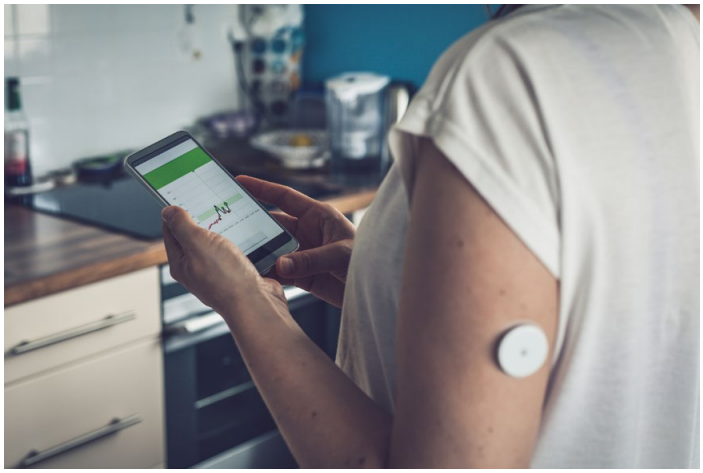
✓ Correct user technique is critical.
✓ The person performing the test must have received training.
✓ A sharps bin should be close to the individual being tested to reduce the risk of sharps injury.
✓ The individual's hand or finger should be washed and dried before commencing the procedure.
✓ BG testing strips should be in date and should display the date of opening.
✓ Strips should be stored at the correct temperature and in manufacturer's packaging.
✓ The lid should be replaced on the container promptly after removing a strip to keep the contents in the correct condition.
✓ A sufficient blood sample should be obtained (using the side of the finger and an appropriate finger pricking device and technique). The lancet should only be used once and then disposed of safely.
✓ The BG meter should show results in mmol/L not mg/dL.
✓ The user should be aware of the degree of error, especially in the low BG range.
✓ The user should know to re-check if symptoms do not tally with BG reading.
✓ People having abnormalities with haematocrit, haemoglobinopathies or anaemia may experience inaccurate readings.
✓ Only specific meters are suitable for people on peritoneal dialysis, so the HCP needs to check with the manufacturer's' guidance.
✓ Every person who is asked to perform glucose or ketone monitoring should be provided with the correct means of safe disposal of their sharps, i.e. lancets.

Table 5: Who should test and how often? (Amended from Leicester Diabetes Centre, 2018).

Typical self-monitoring regimens			
A Periodic testing to meet needs at that time. B 1-2 tests daily, varying times of testing including pre- and 2 hours post-meal. C 4 tests per day x 2 days a week including pre- and 2 hours post-meal. D 4 tests per day each day including pre- and 2 hours post-meal. E 7 tests per day, pre- and post-meals and before bed.			
Type 2 diabetes – Diet and lifestyle management only	**HbA1c and frequency of monitoring**	**Type 1 diabetes – Insulin**	**HbA1c and frequency of monitoring**
Self-monitoring blood glucose (SMBG) is not recommended as part of routine care if HbA1c is within target, but may be useful as an educational tool to understand lifestyle interventions.	Measure HbA1c 3-monthly until target is reached, then monitor 6-monthly.	It is recommended that all people with type 1 diabetes monitor their glucose levels. SMBG may be used to adjust insulin doses prior to meals (e.g. basal bolus therapy and carbohydrate counting, pump therapy, DAFNE patients) and so frequent testing will be required. Less frequent monitoring may be acceptable in more stable type 1 diabetes, depending on the person's daily routine.	HbA1c should be measured 3–6 monthly in all people with type 1 diabetes. Possible regimens: B C D E
Type 2 diabetes – Insulin with/without oral agents	**HbA1c and frequency of monitoring**	**Older people**	**HbA1c and frequency of monitoring**
SMBG is recommended. Regular testing is required at initiation and during adjustment of doses. Frequency may be reduced when glycaemic target reached. Increased testing may be required during intercurrent illness and when there is risk of hypoglycaemia. Adequate training must be provided.	HbA1c should be measured 3-6 monthly. Possible regimens: B C D	Older people and/or carers recently introduced to self-monitoring blood glucose may need support from district nursing teams.	HbA1c should be measured at least every 6 months . The frequency of SMBG will depend on the specific medication prescribed for their diabetes. Possible regimens: A B C
Type 2 diabetes – Oral therapy	**HbA1c and frequency of monitoring**	**Diabetes and pregnancy**	**HbA1c and frequency of monitoring**
If HbA1c is out of target or if there is a risk of hypoglycaemia using oral therapies such as sulphonylureas, consider SMBG. The frequency of testing should be agreed with the individual and adequate training provided. Some people benefit from glucose testing for short periods of time, e.g. when oral medication is changed or adjusted or if the individual is on a course of steroid therapy.	Continue to measure HbA1c 3-6 monthly. Possible regimens: A B C	Pregnant people with type 1 or type 2 diabetes, and those with gestational diabetes. Women with diabetes planning for pregnancy or who are pregnant. HbA1c–test pre-conception and in each trimester.	Frequent testing is required and up to 7 times a day (NICE, 2015c). Possible regimens: D E

NEW TECHNOLOGIES IN GLUCOSE MONITORING

New technologies in glucose monitoring



Stable glycaemic control can be affected by:

- Persistent hyperglycaemia as measured by HbA1c
- Glycaemic variability between days
- Glycaemic instability within the day.

Reducing hyperglycaemia by improving HbA1c alone may result in hypoglycaemia and can lead to frustration and diabetes burnout for the person living with diabetes. The HbA1c level may result in repeated episodes of undetected hypoglycaemia but does not give information on glycaemic variability. Self-monitoring blood glucose provides more evidence, but the amount of testing required can be prohibitive and painful.

Continual glucose monitoring allows the identification of variations in blood glucose levels at 3-5 minute intervals and enables the person to adjust insulin accordingly (Evans et al, 2017).

Interpreting the data from these systems can be difficult so it is important the person using this equipment and their healthcare professionals are familiar with how to interpret the results.

Continuous glucose monitoring

Continuous glucose monitoring system (CGMS) devices use a sensor to transmit a 1-5 minute reading, depending on the product used, to a handheld device, phone or watch. The sensor has a small cannula which is placed into the interstitial space within the subcutaneous tissue. The sensor includes a transmitter that is attached to the skin, and which sends data automatically to a receiver displaying the user's glucose data. Sensors are usually worn for 7 days, but some can be used for 14 days depending on the product used. It is important to remember there may be a time-lag on the reading of 5-15 minutes depending on the equipment in use and clinical status of the individual.

Table 6: Examples of CGMS systems available in the UK.

Continual glucose monitoring: NICE (2008 updated 2011) offers specific guidance on the use of continual glucose monitoring in people with type 1 diabetes over the of age 12. It recommends the use of CGMS in situations where:

- Despite optimising all other testing options there is still more than 1 episode of severe hypoglycaemia in a year with no obvious preventable precipitating cause
- There is complete loss of awareness of hypoglycaemia
- There is frequent asymptomatic hypoglycaemia (>2 per week)
- There is extreme fear of hypoglycaemia
- There is persistent hyperglycaemia (HbA1c level of 75 mmol/mol [9%] or higher) despite testing >10 times a day.

Real-time continuous glucose monitoring should only continue if:

- **HbA1c can be sustained at or below 53 mmol/mol and/or there has been a fall of 27 mmol/mol or more.**
- **It is being provided by a centre with expertise in its use, as part of strategies to optimise a person's HbA1c levels and reduce the frequency of hypoglycaemic episodes.**

The advantages and disadvantages when using CGMS are shown in Table 7.

Table 7: Advantages and disadvantages in using CGMS.

Advantages
Alarms
Instant access to trends and results
Ability to share results with friends/family/carers
Reduced anxiety
Reduction in need for capillary blood glucose testing
Ability to adjust therapy with access to data including: - 3-5 minute data upload of data collection - Trend arrows - Hypo/hyper avoidance - Smart meter capabilities
Reduction in over treatment of hypoglycaemia and hyperglycaemia
Disadvantages
Some sensors react to paracetamol/ibuprofen
If glucose levels are rising or falling quickly, the accuracy of the sensor reading may be affected
If the individual is unwell, i.e. dehydrated, vomiting or has loose stools, then accuracy can be affected
The individual may develop sensitivities to the adhesive

Flash glucose monitoring

Flash glucose monitoring is seen as a hybrid between meters and continuous glucose monitoring. The Abbott FreeStyle Libre is currently the only flash glucose monitoring product available. Libre 2 – an updated system – will be made available in 2020.

In flash glucose monitoring, the person has a sensor inserted onto their upper arm and a separate touchscreen reader device. When the reader device is swiped close to the sensor, the sensor transmits both an instantaneous glucose level and an 8-hour trend graph to the reader. This allows people to get individual glucose readings (like BGM) and trend information (like CGM). However, unlike CGM, flash glucose monitoring does not have hypoglycaemia nor hyperglycaemia alarms and will only provide a trend graph if it has been swiped in the past 8 hours.

Other new technologies in production include a system where a single sensor can be used for 14 hours and readings are updated onto the system every 5 minutes. This information is sent to a smart device via a rechargeable transmitter. Information can then be downloaded via bluetooth. The sensor does not need to be worn every day, just when the user feels they want more information (SugarBEAT®).

The NHS England Regional Medicines Optimisation Committee (RMOC) position statement on flash monitoring systems does not support use in type 2 diabetes. The RMOC recommends that Freestyle Libre should only be used in type 1 diabetes, and in those aged 4 years and above, and users must attend a specialist clinic, and must be deemed to meet one or more specific criteria, in addition to undertaking training and committing to regular follow-up and monitoring (NHS RMOC, 2017). Currently, flash glucose monitoring is only available for people with type 1 diabetes who fit the following criteria:

- Those who undertake monitoring >8 times per day.
- Those who meet the current NICE criteria for insulin pump therapy (HbA1c > 69 mmol/mol) or disabling hypoglycaemia as described in NICE TA151, where successful trial of Freestyle Libre may avoid the need for pump therapy (NHS England, 2019).
- Those who have recently developed impaired awareness of hypoglycaemia. It is noted that for persistent hypoglycaemia awareness, NICE recommend continuous glucose monitoring with alarms and Freestyle Libre does not currently have that function.
- Frequent admissions (>2 per year) with diabetic ketoacidosis (DKA) or hypoglycaemia.
- Those who require third parties to carry out monitoring and where conventional blood testing is not possible.
- People with diabetes who dialyse and are on insulin.

CGMS, flash glucose monitoring and driving

The DVLA issues guidance twice a year. They have included the use of new technologies in the 2020 guidance.

Recent studies of people with type 1 diabetes support the wider use of flash glucose monitoring to improve outcomes, including improved HbA1c, reduced risk of hypoglycaemia, and improved quality of life.

The DVLA has approved the use of CGMS and flash monitoring for the purposes of Group 1 drivers; it is not legally permitted for Group 2 drivers.

Drivers in the Group 1 category are recommended to carry blood testing equipment in the car. They should test blood glucose using a fingerprick sample if there is doubt or concern about glucose levels.

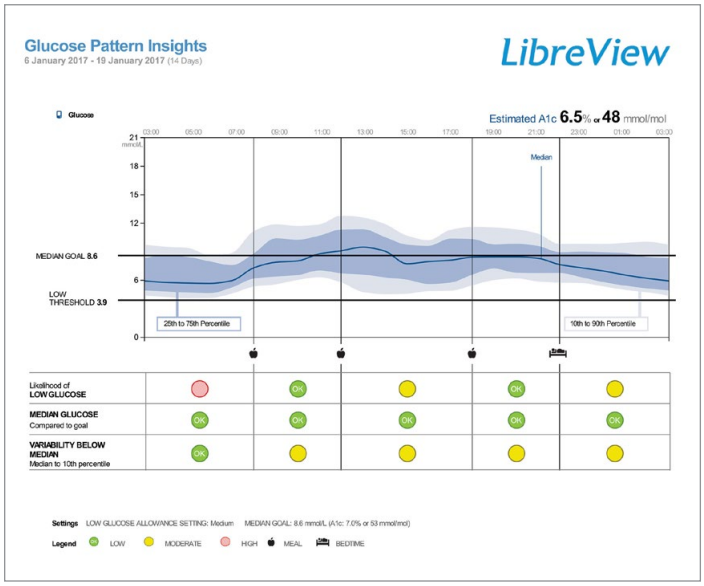
See Table 8 for specific DVLA advice (DVLA 2020).

Table 8: DVLA guidance on CGMS.

Group 1
✔ These systems may be used for monitoring glucose at times relevant to driving. ✔ Users of these systems must carry fingerprick capillary glucose testing equipment for driving purposes as there are times when a confirmatory fingerprick blood glucose level is required. ✔ If using an interstitial fluid continuous glucose monitoring system (FGM or RT-CGM), the blood glucose level must be confirmed with a fingerprick blood glucose reading in the following circumstances: - when the glucose level is 4.0 mmol/L or below - when symptoms of hypoglycaemia are being experienced - when the glucose monitoring system gives a reading that is not consistent with the symptoms being experienced (e.g. where there are symptoms of hypoglycaemia and the system reading does not indicate this) – see INF294 Appendix D, page 125 for further details. Real-time CGM interstitial fluid glucose monitoring systems are not permitted for the purposes of Group 2 driving and licensing.

Interpretation of readings from flash glucose meters

Full instruction of data interpretation will be discussed as part of the Freestyle Libre system set up with the individual by the HCP. Flash glucose readings are displayed in this format:



- The ambulatory glucose profile (AGP) contributes to a systematic approach to interpreting dense glucose data from glucose monitoring systems.
- Consensus recommendations are available to guide the use of the AGP.
- The guidance places emphasis on examination of the AGP for periods of hypoglycaemic risk, i.e. when the 10th centile line for glucose approaches or enters the hypoglycaemic range.
- These analyses are supported by the glucose pattern insights analysis available from the FreeStyle Libre flash glucose monitoring system, which flags up the likelihood of low glucose, the proximity of the median glucose to target, and the degree of variability below the median at various times of day (Hammond, 2016).

KETONE MONITORING

Ketone bodies (acetoacetate and β-hydroxybutyrate) are produced in the liver from the breakdown of fatty acids as a source of energy during fasting, exercise and insulin-deficient states, e.g. in intercurrent illness in people with diabetes. The presence of ketones in urine or blood may signify a risk of diabetic ketoacidosis (DKA). This includes any individual with diabetes who presents to a HCP with an acute illness, for example:

- Flu-like symptoms
- Fever
- Cough
- Nausea/vomiting
- Abdominal pain
- Shortness of breath.

In these circumstances, a blood glucose and urinary or blood ketone test should be undertaken to rule out diabetic ketoacidosis (DKA) or hyperosmolar hyperglycaemic state (HHS).

Diabetic ketoacidosis was considered to be a condition that only affected people with type 1 diabetes, however, a survey of the trends and characteristics in the UK using data from the Clinical Practice Research Datalink (CPRD) and Hospital Episode Statistics (HES) from 1998 revealed that 1 in 5 admissions for DKA had occurred in people with type 2 diabetes (Zhong et al., 2018)

People with type 1 diabetes should have access to blood ketone meters as they need to adjust their insulin in alignment with their ketone readings (NICE NG17, 2017).

There are a variety of blood ketone meters available in the UK, some examples of these are shown below. These meters are designed to test both blood glucose with glucose testing strips and ketones using specific ketone test strips. Urinary ketone testing can be carried out using Multistix/Ketostix, however, it is important to note that blood ketone meters and urine ketone strips measure different ketone bodies and interpretation of the results is not strictly interchangeable. Urinary ketone testing is of limited use depending on when the individual last passed urine.

During times of fasting, intercurrent illness or treatment for DKA, conversion of β-hydroxybutyrate to acetoacetate may initially result in a paradoxical rise in ketone bodies. Blood ketone testing provides a more accurate "real time" ketone result. The blood ketone meter ranges are 0 - 8mmol/L:

✔ NORMAL result = 0.0 - 0.6 mmol/L
⚠ ABNORMAL result = greater than 0.6 mmol/l – the higher the level, the higher risk of DKA

Irrespective of blood glucose readings or diabetes treatments used, if the individual is acutely unwell the healthcare professional should test for either urinary or blood ketones.

If the individual is ketotic (moderate or large urinary ketones or > 0.6 mmol/L), consider admission to hospital for assessment:

- ✔ At diagnosis of diabetes
- ✔ In any person with diabetes who is acutely unwell, irrespective of the blood glucose level, as part of sick day management
- ✔ In people with diabetes with severe nausea/vomiting
- ✔ In acidosis and if there is a history of alcohol excess
- ✔ When screening for euglycaemic diabetic ketoacidosis, e.g. in people prescribed SGLT2i ('gliflozins').
- ⚠ **Pregnant women who have diabetes and who are unwell or vomiting irrespective of BG level should be admitted to hospital for emergency assessment if they have ketones.**

(RMOC, 2017; Dover et al., 2017)

The ketone level determines what action needs to be taken.

Sick day advice and ketone testing advice for people with type 1 diabetes:

- Increase fluids and take hourly, 100mls/hr but sip slowly
- Adjust insulin doses according to ketones (for leaflet click here)
- Ketones:
  - less than 0.6 mmol/L is normal
  - 0.6 - 1.5 mmol/L means they may be at risk of developing DKA so test again after two hours
  - 1.6 - 2.9 mmol/L means they are at risk of DKA and should contact their diabetes team or GP as soon as possible
  - 3 mmol/L means they have a very high risk of DKA and should get emergency help as soon as possible.
- If they are only able to do a urine ketone test, a result of 2+ means they may be at risk of developing DKA.
- ⚠ **If an individual is unable to keep fluids down, admit urgently to hospital.**
- ⚠ **In pregnancy – if ketotic and/or vomiting or unable to keep fluids down, admit urgently to hospital.**
- ⚠ **In children with ketosis – admit urgently to hospital.**

Sick day advice and ketone testing advice for people with type 2 diabetes:

- Take sips of fluid hourly
- May initially need to lower or increase insulin or sulphonylureas (for leaflet click here)
- Irrespective of blood glucose levels or diabetes treatment, if any individual is clinically unwell, test for ketones – if positive, consider emergency assessment
- If an individual is on an SGLT-2 inhibitor and or metformin, temporarily stop the drug
- If the individual is taking an ACE inhibitor or ARB, temporarily stop the drug
- If an individual is acutely unwell and ketotic, admit to A&E for assessment

Sharps disposal

Every person who is asked to perform glucose or ketone monitoring should be provided with the correct means of safe disposal of their sharps (i.e. lancets):

- There are a number of devices that enable the safe disposal of used sharps.
- Sharps disposal boxes are available on FP10 prescription.
- Each local council may have a different collection service; this should be clearly communicated to each person with diabetes who is asked to monitor their BG levels.

The EU Directive 2010/32 became UK law in May 2013; this focuses on the need to provide greater protection to all healthcare workers, downstream workers and others who are at risk of sharps injury (European Union, 2010). The directive sets out to protect patients and workers at risk by ensuring the safest possible working environment. People with diabetes who are monitoring their own BG levels at home or whilst they are out and about should be aware of the dangers of disposing of their sharps inappropriately and should be encouraged to use the correct equipment provided.

SUMMARY

There are a variety of methods used to monitor glucose and ketones in people living with diabetes. Testing alone will not lead to improvements in the glycaemic management or safety of these individuals. Effective testing depends on an individual's, confidence and competence and that of their healthcare professionals in using the technology selected; this includes how to adjust lifestyle and medications to improve diabetes control and quality of life.

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