Routine monitoring of diabetes mellitus in adults at primary health care level, and self-monitoring of blood glucose (SMBG)

Diabetes mellitus is a chronic illness that necessitates chronic long-term medical care and self-management to prevent acute and chronic complications.

TANJA KEMP, ***MB ChB, MMed (Int Med), Cert Endocrinology & Metabolism (SA) Phys***
Senior Specialist, Endocrinology Unit, Department of Internal Medicine, Steve Biko Academic Hospital, Pretoria
Tanja Kemp is a Specialist Endocrinologist working in the Endocrinology Unit of Steve Biko Academic Hospital in Pretoria. She is also a Senior Lecturer at the University of Pretoria. Her special interests include all aspects of diabetes care, as well as pituitary pathology.

Correspondence to: Tanja Kemp (kemp.tanja@gmail.com)

Diabetes care extends beyond glycaemic control, and several interventions to improve diabetes outcome are supported by evidence from large trials.

Most of the recommendations included here are based on the Society for Endocrinology, Metabolism and Diabetes of South Africa (SEMDSA) guidelines for type 2 diabetes, and on those of the International Diabetes Federation (IDF) and the American Diabetes Association (ADA).[1-3] Guidelines for diabetes management are not rigid, and should be modified according to an individual patient's co-morbidities and other patient factors.

Therapeutic targets

Lifestyle, BMI, waist circumference

SEMDSA recommends a BMI of below 25 kg/m^2, and a waist circumference of less than 94 cm in men and less than 80 cm in women.[1] These recommendations are applicable in type 1 diabetes as well. Lifestyle modifications such as adequate exercise and smoking cessation should be advocated at each visit.[3]

Glycaemic targets for control

Why is good glycaemic control necessary?

Large trials in patients with diabetes mellitus have demonstrated the beneficial effect of good glycaemic control on the prevention of microvascular complications. The landmark trials were the DCCT trial in type 1 diabetes, and the UKPDS trial in type 2 diabetes.[4,5] On long-term follow-up the risk reduction for development of macrovascular complications also became statistically significant in the groups initially randomised to intensive glycaemic control.[6,7]

How low should you go? (Tables I and II)

SEMDSA recommends a target HbA_{1c} of 7%.[1] The reason for the more conservative goal is the disappointing results of recent trials which aimed for lower HbA_{1c} values.[8] However, for carefully selected subgroups a lower HbA_{1c} may be targeted, especially early in the course of the disease and in patients with a relatively long life expectancy.

For subgroups who are older, with advanced diabetic complications, especially renal

Table I. SEMDSA guidelines for diagnosis and management of type 2 diabetes mellitus for primary health care – 2009[1]

Glycaemic targets for control*	
Glycated haemoglobin (HbA_{1c}) (%)†	<7
Capillary (finger-prick) plasma glucose (mmol/l):	
Pre-prandial	4 - 7
Post-prandial‡	5 - 8

*For non-pregnant adults.
†Referenced to non-diabetic range of 4 - 6% using a DCCT-based assay (DCCT-aligned).
‡Peak post-prandial levels in people with diabetes are generally 1 - 2 hours after the beginning of a meal.

Key concepts in setting glycaemic targets

- HbA_{1c} is the primary target for glycaemic control. More stringent glycaemic goals (i.e. HbA_{1c} <6.5%) may further lower the risk of microvascular complications like nephropathy, but at the cost of increased risk of hypoglycaemia and increased mortality in patients who are at elevated risk of cardiovascular disease (CVD).
- Post-prandial glucose should be targeted if HbA_{1c} goals are not met despite reaching pre-prandial goal.
- Goals should be individualised based on: duration of diabetes, co-morbid conditions, pregnancy status, hypoglycaemia unawareness, age and individual patient considerations.

Table II. Glycaemic targets for control in type 1 diabetes mellitus*

	ADA[3]	IDF[2]
Glycated haemoglobin (HbA_{1c}) (%)†		
Adults	<7	<6.5
Adolescents	<7.5	<7.5
Adults		
Capillary (finger-prick) plasma glucose (mmol/l)		
Pre-prandial	3.9 - 7.2	<5.5[14]
Post-prandial‡	<10	<7.8[14]
Adolescents		
Capillary (finger-prick) plasma glucose (mmol/l)		
Pre-prandial	5 - 7.2	<7.0[9]
Post-prandial‡		<11.1[9]

*Based on ADA and IDF criteria for type 1 diabetics.
†Referenced to non-diabetic range of 4 - 6% using a DCCT-based assay (DCCT-aligned).
‡Peak post-prandial levels in people with diabetes are generally 1 - 2 hours after the beginning of a meal.

Key concepts in setting glycaemic targets (similar as in SEMDSA guidelines for type 2 diabetes)

- HbA_{1c} is the primary target for glycaemic control. More stringent glycaemic goals (i.e. HbA_{1c}<6.5%) may further lower the risk of microvascular complications like nephropathy, but at the cost of increased risk of hypoglycaemia and increased mortality in patients who are at elevated risk of cardiovascular disease (CVD).
- Post-prandial glucose should be targeted if HbA_{1c} goals are not met despite reaching pre-prandial goal.
- Goals should be individualised based on: duration of diabetes, co-morbid conditions, pregnancy status, hypoglycaemia unawareness, age, life expectancy and individual patient considerations.

failure or serious macrovascular disease, a more conservative HbA_{1c} target may be appropriate. This is also the case in patients with serious recurring hypoglycaemic episodes, brittle diabetes, or hypoglycaemic unawareness.[1-3]

Lipid goals (Tables III and IV)

Why should lipid goals be achieved?

Landmark trials in diabetes have clearly demonstrated the efficacy of statins to reduce the risk of developing macrovascular complications.[4,5] Hyperlipidaemia is also associated with an increased rate of progression of diabetic nephropathy, and statins may possibly slow this down.

What are the targets?

LDL-cholesterol should always be the primary therapeutic target. Guidelines differ slightly in the recommended lipid goals.[1-3] These targets are also applicable in type 1 diabetes, owing to the high lifetime risk of cardiovascular disease in this population.[3,9]

When to treat?

All diabetics with cardiovascular disease should be on statin therapy irrespective of the level of total or LDL-cholesterol. Probably all diabetics above 40 years of age, and definitely all with an additional cardiovascular risk factor, should be on a statin.[1-3] Patients under 40 years who don't reach a target LDL after diet and lifestyle modifications or who have multiple cardiovascular risk factors should be treated as well.[1-3]

In adolescents, ADA recommends firstly diet and lifestyle modifications if the LDL-cholesterol is above target.[3] Statins can be used after the age of 10 if the LDL-cholesterol exceeds 4.1 mmol/l, or is above 3.4 mmol/l in the presence of other cardiovascular risk factors.[3] Fibrates can be added after reaching the LDL-cholesterol target, if the TG level exceeds 2 mmol/l.[1]

Blood pressure goals

Why target the blood pressure?

Good blood pressure control is critical in preventing microvascular and macrovascular complications and to decrease its rate of progression. Blood pressure targets have to be achieved even if this necessitates the use of multiple antihypertensive drugs from different classes.[1-3]

How low should you go?

SEMDSA recommends goal systolic blood pressure values of less than 130 mmHg and diastolic values of less than 80 mmHg.[1] In children or adolescents the aim should be to keep the blood pressure below the 90th percentile for age.[3,9] A target systolic blood pressure of less than 120 mmHg and a diastolic value of less than 70 mmHg are

Table III. SEMDSA guidelines for diagnosis and management of type 2 diabetes mellitus for primary health care – 2009[1]

BMI, waist, lipid and blood pressure goals			
BMI and waist		Total cholesterol	<4.5 mmol/l
BMI	<25 kg/m^2	LDL-cholesterol	<2.5 mmol/l†
Waist	<94 cm men*	HDL-cholesterol	>1.0 mmol/l (men)
	<80 cm women		>1.2 mmol/l (women)
		Triglycerides	<1.7 mmol/l
Blood pressure‡			
Systolic	<130 mmHg		
Diastolic	<80 mmHg		

*<90 cm in men of South Asian descent.

†In the presence of clinically manifest vascular disease (ischaemic heart disease, cerebrovascular disease or peripheral vascular disease) the target should be LDL-cholesterol <1.8 mmol/l.

‡The target blood pressure in diabetic nephropathy is systolic ≤120 mmHg and diastolic ≤70 mmHg.

Table IV. BMI, waist, lipid and blood pressure goals in type 1 DM*

			ADA[1]	IDF[2]
BMI and waist				
BMI	<25 kg/m^2			
Waist	<94 cm men†			
	<80 cm women			
Blood pressure§				
Systolic	<130 mmHg	LDL-cholesterol‡	<2.6 mmol/l	<2.5 mmol/l
Diastolic	<80 mmHg	HDL-cholesterol	>1.0 mmol/l (men)	>1.0 mmol/l (men and women)
ADA[3]	Adolescents:		>1.3 mmol/l (women)	
	<90th percentile for age			
IDF[2,9]	<95th percentile for age	Triglycerides	<1.7 mmol/l	<2.3 mmol/l

*Based on ADA and IDF criteria for type 1 diabetes.

Similar as in SEMDSA guidelines for type 2 diabetes:

†<90 cm in men of South Asian descent

‡In the presence of clinically manifest vascular disease (ischaemic heart disease, cerebrovascular disease or peripheral vascular disease) the target should be a LDL-cholesterol <0.8 mmol/l.

§The target blood pressure in diabetic nephropathy is systolic ≤120 mmHg and diastolic ≤70 mmHg.

Table V. SEMDSA guidelines for diagnosis and management of type 2 diabetes mellitus for primary health care – 2009[1]

Key processes of care (all initially)	
Tests/procedures	**Frequency**
HbA_{1c}	At least 2 times/year if stable
	Quarterly if treatment changes or not meeting goals
Lipid profile	Annually, or more frequently if lipids are high and after treatment has been initiated
Blood pressure	Measure at every routine diabetes visit
Weight/BMI/waist	Weigh and measure waist at each regular diabetes visit BMI annually
Comprehensive foot examination	Annually, or more often in patients with high-risk foot conditions
Microalbumin	Annually if no persistent dipstick proteinuria
Serum creatinine	Annually
Eye examination for retinopathy	Annual or more frequent if significant retinopathy present
Referral to diabetes nurse educator and dietician	Annually or whenever needed

Table VI. Key processes of care for type 1 diabetes mellitus*

Tests/procedures	Frequency ADA[3]	 IDF[2,9]
HbA_{1c}	At least 2x/year if stable Quarterly (4x/year) if treatment changes or not meeting goals or unstable	Every 2 - 6 months, depending on stability and on the level (2 - 4x/year in adolescents)
Lipid profile	Start at 10 years of age (from age 2 if family history of hyperlipidaemia); if normal in children, repeat after 5 years Annually after 18 years of age; if low risk profile, can repeat every 2 years	Start at 12 years of age (from age 2 if family history of hyperlipidaemia); if normal in children, repeat after 5 years Annually from adulthood
Blood pressure	Measure at every routine diabetes visit	At least annually Measure at every routine diabetes visit if on therapy
Weight/BMI/waist/height	Weigh and measure waist at each regular diabetes visit BMI annually Children: measure height (growth chart)	Weigh and measure waist at each regular diabetes visit BMI annually Children: measure height (growth chart)
Comprehensive foot examination	Annually, or more often in patients with high-risk foot conditions	Annually, or more often in patients with high-risk foot conditions
Microalbumin	Annually Start at age 10 and if DM has been present for 5 years	Annually Start at age 11 and after 2 years' diabetes duration
Serum creatinine	Annually	Annually
Eye examination for retinopathy	Start at age 10 and within 5 years of onset of DM Annual or more frequent if significant retinopathy present	Start at age 11 and after 2 years diabetes duration Annual or more frequent if significant retinopathy present
Referral to diabetes nurse educator and dietician	Annually or whenever needed	Annually or whenever needed
Screening for coeliac disease (children/ adolescents)	Tissue transglutaminase or anti-endomysial antibodies after diagnosis of DM	Screening at time of diagnosis and then yearly for 5 years, then less
Thyroid function test (children/ adolescents)	TSH measurement after diagnosis Screen 1 - 2 yearly	TSH measurement after diagnosis Screen every 2nd year

*Based on ADA and IDF guidelines for type 1 diabetics.

Table VII. Self-monitoring of blood glucose (SMBG)*

- SMBG results must be used for the purpose of attaining and maintaining glycaemic targets, by guiding self and practitioner adjustment of therapy and to provide evidence on hypoglycaemia
- SMBG should be done 3 or more times daily for patients using multiple (≥2) daily injections of insulin
- SMBG should be done up to once daily for patients using a single daily injection of insulin either alone or in combination with oral agents
- SMBG can be considered in patients using oral agents (e.g. for assessing if additional Rx is required; to confirm hypoglycaemia if symptomatic), but NOT regularly and indefinitely
- Perform SMBG more frequently in setting of:
  - Acute illness
  - Periods of poor glycaemic control
  - Frequent hypoglycaemic episodes
  - Pregnancy
  - Any adjustment to therapy

Continuous glucose monitoring (CGM)†

- CGM should not replace SMBG at this stage
- CGM can be useful in selected adults older than 25 years with type 1 diabetes to lower the HbA_{1c}
- CGM can be used in combination with SMBG in patients with frequent hypoglycaemic episodes, or with hypoglycaemic unawareness

*SEMDSA guidelines
†Based on ADA guidelines.

recommended for patients with diabetic nephropathy.[1]

Key processes of care (Tables V and VI)

Type 2 diabetes

Clinical processes of care

All key processes of care should be initiated in patients with type 2 diabetes shortly after diagnosis. Blood pressure measurements as well as the weight and waist measurements should be taken at each routine visit, with calculation of the BMI annually. A comprehensive foot examination should be performed annually, but more often in patients with high-risk foot conditions. A dilated eye examination should be performed yearly; more frequent examinations will be necessary if significant retinopathy is present. Referral to a diabetic nurse educator and/or dietician should preferably occur annually.[1-3]

Laboratory tests

In type 2 diabetics, the HbA_{1c} should be measured twice a year if it is stable and on target.[1-3] The frequency can be increased to 2 - 3-monthly if the value is unstable, not on target, or following a therapeutic adjustment. This practice is also appropriate for type 1 diabetes with the higher frequency of testing usually advised for children or adolescents.[9]

The lipid profile should be obtained once a year and after therapeutic adjustments.[1-3] If the lipid profile is considered to convey a low risk to the patient, it can possibly be repeated every 2nd year.[3] Serum creatinine should be measured annually as well as urine microalbumin if no persistent dipstick proteinuria is present.[1]

Type 1 diabetes

The key processes of care are very similar to those in type 2 diabetes.[3,9] Target organ damage is rare within the first few years after diagnosis or before puberty, so most of the screening can be initiated after diabetes duration of 2 - 5 years. In children and adolescents the height and growth velocity should also be charted. The first screening lipogram can be performed at the age of 10 or 12 years if there is no family history of hyperlipidaemia, and after at least 2 years of diabetes duration.[3,9] From 18 years onwards it should be performed annually. Annual screening for microalbuminuria should start from age 11 years and after 2 years of diabetes duration. A serum creatinine should be performed annually in adults. In children and adolescents with type 1 diabetes, thyroid disease and coeliac disease should be excluded.[3,9]

Self-monitoring of blood glucose (SMBG) (Table VII)

SMBG is an important component of intensive glycaemic control. This is usually performed through intermittent capillary blood sampling and the use of a glucometer. SMBG is only effective if both the patient and medical practitioner are able and motivated to use the information to adjust therapy or diet.[1,3,10]

In whom?

Type 1 diabetes

The effectiveness of SMBG in improving glycaemic control in type 1 diabetes has been well established, usually as part of a self-management programme.[4,6,9]

Type 2 diabetes

The benefit of SMBG in improving glycaemic control is less clear than in type 1 diabetes. Multiple trials of SMBG in type 2 diabetes, some of which included patients on insulin, had conflicting results, some demonstrating beneficial effects and others none.[11-13] SMBG might be unnecessary for patients who are not on medications that cause hypoglycaemia.[1] It is also unlikely to be cost effective if performed on all diabetics, although that is debatable.[10,11]

Why perform SMBG?

All patients with diabetes mellitus who use insulin should measure their blood glucose levels to modify behaviour and to help maintain good glycaemic control, to adjust medications, and to prevent and diagnose hypoglycaemic episodes. Even in some motivated patients not on insulin, SMBG can be an important tool.[3,10]

How often?

Most guidelines recommend that patients using multiple insulin injections should monitor their blood glucose at least 3 times daily.[1-3] IDF recommends testing 4 - 6 times a day in younger patients with type 1 diabetes.[9] Most patients will require testing before and at intervals after meals, before, during and after exercise, and occasionally during the night; this will provide useful information for adjusting insulin and carbohydrate intake.

During acute illnesses SMBG has to be done more frequently. If the glucose remains above 14 mmol/l, measurement of urinary ketones should also be performed.[9] Patients who are treated with once-daily insulin can monitor their blood glucose up to once daily; this is also recommended by the ADA for patients on drugs associated with hypoglycaemia.[3] SEMDSA recommends that SMBG should not be performed regularly or indefinitely in patients who are only on oral agents.[1]

Timing of SMBG (Table VIII)

This will depend on the insulin regimen that the patient is on, the glycaemic targets (intensive control versus standard care), the patient's compliance, diet and lifestyle, whether there are frequent hypoglycaemic episodes, and whether therapeutic changes are contemplated.

Once- or twice-daily insulin regimens

For type 2 diabetics on only once-daily insulin, a fasting glucose value in the morning may be sufficient. However, if the fasting glucose values are satisfactory but the HbA_{1C} is not, this usually implies postprandial hyperglycaemia.[1,10] The patient should then test in addition 1 - 3 times a day 2 hours post-prandially. If post-meal hyperglycaemia is confirmed therapy can be changed to biphasic insulin twice a day, or one or more doses of short-acting insulin can be added pre-prandially.

Patients on biphasic insulin should also test fasting blood glucose levels and post-prandial levels at intervals. While diabetes control is poor the first priority should be to normalise the fasting glucose values, which contribute most to the HbA_{1C} at high levels. Once the HbA_{1C} decreases the post-prandial glucose levels become a larger contributor towards the HbA_{1C}, and control of post-meal hyperglycaemia is essential for achieving glycaemic targets.[14]

Basal-bolus regimens

In patients on basal-bolus regimens, meal-based testing is most helpful. Traditionally, type 1 diabetics were requested to test their blood glucose levels mainly pre-prandially to be able to adjust insulin doses for the expected carbohydrate intake and to correct for pre-meal hyperglycaemia. The detrimental effect of post-prandial hyperglycaemia and its role in the development of diabetic complications are now known, therefore post-prandial values should also be evaluated.[14] There are different ways to do this: a 7-point profile is usually only practical for a short period of time. A staggered approach can be used where different meals are evaluated on different days.[10]

Limited resources

Several blood glucose values performed on the same day are often more useful for evaluation of therapy than a single daily value. If resources are limited, especially access to glucose sticks, the decision can be made to test only when the patient is symptomatic and to reduce regular testing to a few times per week.

Table VIII. Examples OF SMBG regimens[1-3,10,14]

Day	Pre-breakfast	Post-breakfast	Pre-lunch	Post-lunch	Pre-supper	Post-supper	Bedtime
Fasting only testing							
Monday	X						
Fasting and post-prandial testing							
Monday	X	X		X		X	
Meal-based testing[10]							
• Lower intensity testing							
Monday	X	X					
Tuesday			X	X			
Wednesday					X	X	
• 5-point profile							
Monday	X	X		X	X	X	
• 7-point profile							
Monday	X	X	X	X	X	X	X

Another approach is to let the patient keep a 5- or 7-point profile for a few days before routine clinic visits, to assist with decisions on therapy. Urinary measurement of glucose is not recommended; it will only demonstrate retrospectively if the blood glucose was above the renal threshold for excretion.[10]

Documentation of SMBG

Unless blood glucose patterns are frequently reviewed and therapy adjusted accordingly, SMBG will not fulfil its purpose.[10] The patient must preferably keep a home profile, and patterns can be detected if the blood glucose values are entered in columns corresponding to times of the day and the relationship to food intake (before and/or 2 hours after a meal).[9] Many glucometers provide data that can be downloaded onto a computer, allowing graphic representation of glycaemic variation by time of day, or over a period of weeks, allowing the visualisation of trends.

Continuous glucose monitoring (CGM)

Devices have been developed that can measure blood glucose on a continuous basis (CGM). In some studies the use of these devices was associated with fewer hypoglycaemic episodes and better glycaemic control in adults, but there are concerns about reproducibility of glucose values especially in the lower glucose range.[3,15] At this stage it is advised that these devices should not be relied on exclusively for blood glucose monitoring. Patients must continue to perform SMBG to verify the accuracy of the sensor readings.

References available at www.cmej.org.za

In a nutshell

- Lifestyle modifications should be addressed regularly, including weight loss if necessary, smoking cessation, diet and regular exercise.
- Good glycaemic control decreases the risk for microvascular complications and to a lesser degree also macrovascular complications in type 1 and type 2 diabetes.
- Glycaemic targets can be adjusted for certain subgroups depending on patient factors such as life expectancy, the presence of advanced complications, and of hypoglycaemic episodes.
- Obtaining a target LDL-cholesterol should be the main priority with statin use.
- Strict blood pressure control should be maintained even if several classes of drugs have to be used.
- Key processes of care should be adhered to according to guidelines.
- All diabetic patients on two or more insulin injections per day should self-monitor their plasma glucose levels three or more times a day.
- Patients on a single insulin dose per day, either alone or combined with oral agents, may benefit from up to once daily glucose self-monitoring.
- To patients on only oral glucose-lowering drugs, SMBG might be useful for short periods to confirm hypoglycaemia or to assess the need for additional therapy, but shouldn't be used indefinitely.
- More frequent self-monitoring may be necessary under special circumstances, such as acute illness, pregnancy, or recurring hypoglycaemic episodes.