Recommendations for Managing Patients With Diabetes Mellitus in Cardiopulmonary Rehabilitation

AN AMERICAN ASSOCIATION OF CARDIOVASCULAR AND PULMONARY REHABILITATION STATEMENT

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■ Diabetes mellitus is a highly prevalent condition in patients participating in cardiopulmonary rehabilitation. However, research and subsequent guidelines specifically applicable to patients with diabetes, participating in cardiopulmonary rehabilitation, are limited. Recognizing this limitation, the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) initiated this statement, with the goal of developing a template that incorporated recommendations provided in the AACVPR Core Components and the American Association of Diabetes Educators 7 Self-Care Behaviors. This statement describes key processes regarding evaluation, interventions, and expected outcomes in each of the core components for the management of patients with diabetes in a cardiopulmonary rehabilitation program.

K E Y W O R D S

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Diabetes mellitus (DM) is identified as a risk equivalent of coronary heart disease and many patients with diagnosed coronary heart disease have a diagnosis of DM or are at risk for diabetes.[1,2] Among US residents in 2010, age 65 years and older, 10.9 million (26.9%) had diabetes. In addition, DM is a highly prevalent condition in cardiopulmonary rehabilitation and is likely to remain so.[3] A report from the Montana Cardiac Rehabilitation Regional Outcomes Project showed that 27% (N = 2097) of the patients entering cardiac rehabilitation presented with a diagnosis of diabetes.[4] Audelin et al[5] reported an diabetes incidence of 25.4% (N = 532) in 2008 in patients entering cardiac rehabilitation, with a 52% increase over a 10-year period.

Although mortality from cardiovascular disease has declined, the proportion of patients with a major cardiovascular event, who also have DM, has increased.[3] Cardiovascular events in people with diabetes also appear to be associated with less favorable outcomes compared with the nondiabetic population.[6-9] The presence of DM or low exercise capacity independently predicts mortality from cardiovascular complications, namely, heart failure, angina, acute myocardial infarction, cardiac arrhythmia, and stroke.[10,11] With the overall number of people with diabetes predicted to increase, programs are likely to serve an increasing number of patients with diabetes.[12]

The cardiopulmonary rehabilitation setting presents health care providers with the opportunity to assist in the identification of people at risk for diabetes or who have DM, as well as aiding in the management of associated risk factors and the disease process itself.[13] The frequent contacts between program staff and patients facilitate appropriate referrals for assessment by a dietitian and/or certified diabetes educator (CDE), ongoing followup, and participation in the monitoring and management of DM.[3,14] Exercise, a core component of cardiopulmonary rehabilitation programs, also has a favorable impact on blood glucose (BG) levels and is a class I indication in the management of DM.[2]

The American Association of Cardiovascular and Pulmonary Rehabilitation formed a multidisciplinary panel to review the literature and provide evidence-based guidance for managing glycemic control with exercise, and educating patients about risk factors associated with diabetes, within the cardiopulmonary rehabilitation setting. It is expected that detailed and unit-specific protocols for the management of patients with DM may improve services for these patients, as special considerations are often required because of the increased mortality associated with cardiovascular disease.[7] This "cardiodiabetological" approach is of utmost importance for the sake of these patients as they begin secondary prevention of their chronic diseases. The complexity of managing a patient with cardiovascular disease and diabetes requires a multidisciplinary team. As such, the cardiopulmonary rehabilitation team can provide important clinical guidance to the overall management of these patients. While it is recognized that all program staffs may not have the same access to resources for diabetes management and education, the following recommendations should assist and support these clinicians in the process of the management of DM.

CLASSIFICATION AND DIAGNOSTIC CRITERIA FOR DM

Diabetes mellitus is characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The American Diabetes Association (ADA) provides classification criteria (Table 1) and diagnostic criteria (Table 2) for DM.

DIABETES CONSIDERATIONS IN THE CARDIOPULMONARY REHABILITATION SETTING

Initial Patient Assessment at Program Entry

A key recommendation for patients with DM is optimal BG control. An important role of the cardiopulmonary rehabilitation team is to assess risk factors for recurrent coronary events and guide patients in risk modification.[15-17]

Table 1 • American Diabetes Association Diabetes Classification[a]

Type 1 diabetes	Marked by autoimmune β-cell destruction that usually leads to absolute insulin deficiency
Type 2 diabetes	A result of a progressive insulin secretion defect on the background of insulin resistance
Gestational diabetes	Diabetes diagnosed during pregnancy that is not clearly overt diabetes (this may be a risk factor to address if educating about diabetes prevention)
Other specific types	Diabetes due to other causes, for example, genetic defects in β-cell function, genetic effects in insulin action, diseases of the exocrine pancreas (such as cystic fibrosis), and drug- or chemical-induced (such as in the treatment of AIDS or after organ transplantation)

Abbreviations: BG, blood glucose; DM, diabetes mellitus; AIDS, acquired immune deficiency syndrome.
[a]Based on information from the American Diabetes Association.[2]

Table 2 • American Diabetes Association Criteria for the Diagnosis of DM[a]

1. Hemoglobin A1c 6.5%[a] or more; or
2. Fasting BG 126 mg/dL or more. Fasting is defined as no caloric intake for at least 8 hours[b]; or
3. A 2-hour BG 200 mg/dL or more during an oral glucose tolerance test[b]; or
4. In a patient with classic symptoms of hyperglycemia or hyperglycemic crisis, a random BG 200 mg/dL or more

Categories of increased risk for diabetes[b]

1. Impaired fasting glucose, for example, fasting BG between 100 and 125 mg/dL
2. Impaired glucose tolerance, for example, 2-hour oral glucose tolerance test result between 140 and 199 mg/dL
3. Hemoglobin A1c between 5.7% and 6.4%

Abbreviation: BG, blood glucose; DM, diabetes mellitus.
[a]Based on information from the American Diabetes Association.[2]
[b]In the absence of unequivocal hyperglycemia, criteria 1, 2, and 3 should be confirmed by repeat testing.

Patients with DM have an increased risk of primary and secondary coronary heart disease, an increased risk of depression which can lead to poor choices regarding medication and lifestyle modifications, and a higher incidence of cerebrovascular disease, as well as other microcirculatory and comorbid complications such as neuropathy, nephropathy, and retinopathy.[18] Patient with DM may have developed long-term complications that make cardiopulmonary rehabilitation more challenging. Examples include blindness, nephropathy, peripheral neuropathy with decreased sensation, deformities, vascular disease with severe claudication or limb amputation, and cardiac autonomic neuropathy characterized by resting tachycardia, inability to increase the heart rate in response to exercise, and orthostatic hypotension.[18-20]

Baseline assessment of risk factors and exercise capacity can provide valuable information for the physician in stratifying risk and managing patients with coronary heart disease.[15,21] This information can also assist the health care team in determining the individual needs for BG monitoring, appropriate nutrition options, DM medication adjustments, and self-management skills.[22,23] Self-management skills depend on patient ability to accept the diagnosis and actively manage the disease. A combination of behavioral and medical interventions is particularly effective in reducing cardiovascular risk. The challenge for the clinician is how to help the patient acquire and master the skills needed to sustain lifestyle changes. Assessing the ability of the patient to manage the 7 self-care behaviors outlined by the American Association of Diabetes Educators[24] including healthy eating, being active, monitoring, taking medication, problem solving, reducing risks, and healthy coping, can help identify learning deficits and need for referrals. When available, a dietitian or CDE can provide valuable expertise. Working with the patient and staff, a plan of care can be formulated that addresses educational deficits, provides clinical recommendations, and supports behavior change. Self-management topics that can be initiated with patients with diabetes to motivate the changes necessary to achieve independence appear in Table 3.

Blood Glucose Monitoring

Blood glucose values provide valuable information to the cardiopulmonary rehabilitation team prior to and following the exercise session, or at any time symptoms should arise. However, there are no published guidelines indicating the frequency of BG measurements within the cardiopulmonary rehabilitation setting. However, monitoring is useful to establish patterns for glucose response and potentially to prevent hypoglycemia.[30] Determining how often a person should test BG should be individually assessed on the basis of patient medications, comorbid conditions, medical history, meal plan, time of exercise, and history of hyperglycemia and hypoglycemia. This information should be considered on an ongoing basis for evaluation and possible adjustment of either the exercise program or DM care plan. Patients should also receive education regarding the need for BG testing during planned or unplanned exercise outside the formal exercise setting.[30,31] The recommendations provided in this statement can be used to establish BG monitoring policy which should reflect individual program policies and procedures which best fit the institutional setting.

Blood Glucose Interpretation

Blood glucose monitoring before and after an activity allows oversight of the glycemic response to a single bout of exertion. If readings remain lower than 100 mg/dL postexercise in patients on insulin, secretagogues, or both, or if patients have symptoms of hypoglycemia or if preexercise readings are higher than 300 mg/dL after the first few sessions, the physician should be notified and guidance provided for medication adjustment or a prescription for individual BG guidelines. Additional periods of BG monitoring may be necessary when a medication change occurs or if hypoglycemia is expected.[30,32]

Evaluating and treating BG response should be individualized on the basis of medical history, the presence of comorbid conditions, medication use, dietary intake, and history of exercise-induced hypoglycemia. The referring physician or provider, endocrinologist, CDE, or dietitian can assist the rehabilitation team in developing the treatment plan and should be included when evaluating and setting BG targets.[33] Patients who have a history of hypoglycemia unawareness may benefit

Table 3 • Diabetes Self-management Assessment Topics

Medical history	• Diagnosis and duration: type 1 diabetes, type 2 diabetes • Hemoglobin A1c or estimated average glucose values, recent BG values or readings • Presence of comorbid conditions, neuropathy, retinopathy, and nephropathy; last examination for vision, dental, and feet
Assessment and intervention	• Is the patient seeing a physician for regular health screenings? Provide patient with the American Diabetes Association–recommended screening guide • Is the patient at goal range for hemoglobin A1c? (American Diabetes Association recommends A1c under 7.0% and the American Association of Clinical Endocrinologists under 6.5%) • If not, what resources are available to support patient in reaching that goal (CDE, dietitian, education classes)? • Does the patient have comorbid conditions that can impact the exercise session? Modify the exercise prescription/plan to accommodate any identified problems
Nutrition management	• Impact of nutrition on BG • Weight loss or gain, amount desired • Use of food diaries • Prevention of weight regain • Referral to dietitian • History of bariatric surgery[25]
Assessment and intervention	• Does the patient understand appropriate BG levels for exercise and how nutrition can impact this? • Is the patient monitoring postprandial BG as needed? Postprandial BG can be used to educate and help the patient understand the impact of meals on BG; BG should be taken before the meal and 2 hours after starting the meal; goal BG range at 2 hours after eating is less than 140 mg/dL (per American Association of Clinical Endocrinologists) to less than 180 mg/dL (per American Diabetes Association) • Does the patient have the proper skills and resources to maintain weight loss goals? If not, provide appropriate referrals
Exercise	• Relationship between exercise and BG • Goal ranges for BG and activity • Amount and type of activity • Safety precautions
Assessment and intervention	• Review goal range for BG with exercise; help patient identify patterns of BG response and how to plan meals/snacks around exercise to prevent unnecessary treatment of hypoglycemia • Does patient understand carbohydrate requirements for prolonged and/or intense exercise? Help patient determine the intensity and duration of the activity, review patient previous response to activity, and type and amount of carbohydrates needed to sustain adequate BG • What are the implications of patient comorbid conditions? What safety precautions are needed to prevent injuries? Patients with peripheral neuropathy may need more emphasis on nonweight-bearing exercises; patients with hypoglycemia unawareness and may a higher preexercise BG level
Use of BG monitoring	• Type of meter in use at home • Frequency and timing of BG readings • Read meter insert for any drug and disease interactions causing faulty readings[26,27] • Assess patient knowledge and ability in performing quality control checks with glucose control solution and calibration of glucose monitor if warranted • Record keeping and interpretation of glucose results
Assessment and intervention	• Is the patient proficient in self-monitoring? Staff or patient should assess glucose meter accuracy according to manufacturer instructions; this information can be found in the instruction manual or by calling the customer support phone number • Assess patient readiness to learn and apply self-management skills
Medications	• Understanding of medication action and potential for adverse effects, with special attention to concomitant medications that affect glycemic control • Referral to appropriate resources for financial assistance as needed
Assessment and intervention	• Team should perform medication reconciliation to ensure accuracy and have a current list of patient medications; patients should be given copy of reconciled medication list and asked to carry it at all times • Having the patient speak with his/her health care provider may help medication compliance
Specific details of insulin use, if prescribed	• Delivery device for injection (vial and syringe, insulin pen, pump) • Time of day insulin injected (bedtime, premeal, correction doses) relevant to insulin action pattern and duration

(*continues*)

Table 3 • Diabetes Self-management Assessment Topics (*Continued*)

Assessment and intervention	• Will the insulin peak when patient is exercising? Adjustments may be needed • Has the patient seen a dietitian, CDE, or both? Refer to dietitian, CDE, or both as early as possible for additional support and expertise
Preventive foot care	• Annual foot care/comprehensive examination[2] • Importance of daily foot monitoring[29] • Seek care from a foot specialist for the treatment of callus formation, hammertoes, bunions, Charcot foot, foot ulcers, wound care, and so forth • Seek care from a foot care specialist or other resource if patient is unable to see the plantar surfaces of the feet or reach the feet to perform adequate hygiene, including toenail trimming[29]
Assessment and intervention	• Is patient seeing a podiatrist? Instruct patient to examine feet every day for sores, blisters, cuts, and so forth; patient will need to report changes to physician
Coping strategies	• Identify barriers for change such as depression, low socioeconomic status and/or illiteracy • Need for adaptive devices such as magnifiers, large-display glucose meters, and insulin pens • Additional social support needed such as referral to mental health professional, support groups, or community agencies
Assessment and intervention	• Provide information where patient can find support such as the American Association of Diabetes Educators and American Diabetes Association • Follow institutional policy for referrals

Abbreviations: BG, blood glucose; CDE, certified diabetes educator.

from setting a higher pre-exercise BG goal to decrease the risk of hypoglycemia.[34] Patients presenting with hypoglycemia or hyperglycemia can be challenging for the rehabilitation team. Tables 4 through 9 can be used in the cardiopulmonary rehabilitation setting to set BG guidelines until a pattern of response is established.

Diabetes Medications

Diabetes medications along with recommendations for lifestyle management, including exercise, are frequently prescribed for patients with DM, (Tables 11 and 12). While infrequent, the occurrence of significant symptomatic hypoglycemia during cardiopulmonary rehabilitation, which may exacerbate with exercise, is a clinical concern. There are also various diabetes medications that present a higher risk for hypoglycemia, such as insulin and sulfonylureas. Cardiopulmonary rehabilitation clinicians should develop a plan to prevent and treat hypoglycemia, which may require an individualized approach for certain patients. Potential drug interactions may also increase risk of hypoglycemia or other adverse effects, for example, the combination of alcohol

Table 4 • Preexercise Hypoglycemia Care

Preexercise	Plan of Care	Intervention
Patients using oral agents, insulin, or both that increase the risk of hypoglycemia should maintain BG levels during exercise at 100 mg/dL or higher[2]	Assess patient for individual risks for low BG: • Medication use • Time and content of last meal or snack	Increase and/or maintain appropriate BG levels during exercise by: • Exercise after eating a meal or eating a snack of 15 grams of carbohydrate (with some fat and protein) before exercising, for example, 1 tablespoon of peanut butter and 6 crackers
BG should be taken just before exercise	Establish strategies for BG values of 100 mg/dL or less; encourage patient to look for patterns in his or her BG response	Individual BG targets should be set
Patients with a history of hypoglycemia unawareness or frequent symptomatic hypoglycemia	Assess patient level of understanding and discuss signs and symptoms of low BG and treatment if needed[32]	Patient may require a higher BG target, test, or both during the exercise session and treat accordingly
Patients using insulin pumps	Consult with endocrinologist or CDE for instructions on insulin dose adjustment related to exercise	Every effort should be made to set appropriate BG targets to prevent hypoglycemia from interfering with the exercise session and performance[32]

Abbreviations: BG, blood glucose; CDE, certified diabetes educator.

Table 5 • Postexercise Hypoglycemia Care

Postexercise	Plan of Care	Intervention
Glycemic goal postexercise should be individualized	BG should be taken within 15 minutes after exercise	Encourage patients to test BG frequently after exercise to be aware of the potential for a hypoglycemic response that can last 24 to 48 hours after exercise session[25,30,35]
A postexercise BG goal of 100 mg/dL or higher can be used to discharge the patient if asymptomatic until a BG pattern and response have been established	Use clinical discretion for the discharge of patients on oral hypoglycemic medication if BG is 100 mg/dL or lower and the individual is asymptomatic; caution should be taken discharging patients on insulin if BG is 100 mg/dL or lower	Carbohydrate snacks to prevent hypoglycemia may contain some protein, fat, or both; carbohydrate snacks to treat hypoglycemia are more rapidly digested and absorbed if they are pure carbohydrate; to prevent hypoglycemia during extended activity, a snack of 15 to 30 grams of carbohydrate should be eaten for every 30 to 60 minutes of physical activity[32,33]
Patients using insulin pumps	Patients using pumps should consult with their endocrinologist or CDE for instructions on insulin dose adjustment related to exercise and BG targets	Discuss with patient physician whether insulin or other medication needs to be reduced before the exercise session; obtain specific goals for exercise blood glucose

Abbreviations: BG, blood glucose; CDE, certified diabetes educator.

and phenytoin (Dilantin) in increasing the risk of hypoglycemia.[38-40] Because potassium is critical for insulin secretion, thiazide diuretics may affect glucose metabolism, especially if the patient becomes potassium deficient. Prednisone, which is commonly used in the treatment of chronic obstructive pulmonary disease, may also cause insulin resistance, hyperglycemia, and changes in the lipid profile.[40]

The concerns regarding β-blocker use in patients with DM continue to be debated. The risk imposed by

Table 6 • Hypoglycemia Recommendations

Points for consideration

- Treatment of hypoglycemia (BG < 70 mg/dL) requires ingestion of glucose or carbohydrate-containing foods; rapid glycemic response correlates better with the glucose content than with the carbohydrate content of the food; ongoing activity of insulin or insulin secretagogues may lead to recurrence of hypoglycemia unless further food is ingested after recovery[2]; people on an alpha glucosidase inhibitor (Precose[acarbose]/Glyset [miglitol]) must use dextrose only (such as glucose tablets) for treatment of hypoglycemia
- The "15 grams of a rapidly digested (such as apple juice) carbohydrate, wait 15 minutes" rule, giving 15 to 20 grams of a rapidly digested carbohydrate is the preferred treatment for the conscious individual with hypoglycemia, although any form of carbohydrate that contains glucose may be used; if BG 15 minutes after treatment shows continued hypoglycemia, the treatment should be repeated; once BG returns to normal, the individual should consume a meal or snack to prevent recurrence of hypoglycemia[2]

Examples of 15-gram glucose

- 1/2 cup, or 4 ounces (120 mL), of fruit juice
- 1/2 cup, or 4 ounces (120 mL), of a regular—not diet—soft drink
- 1 cup, or 8 ounces (240 mL), of milk
- 5 or 6 pieces of hard candy
- 3 to 4 glucose tablets (check label for how many tablets equal 15 grams)

Intervention

- Assist patient to determine amount of food, drink, or glucose tablets that equal 15 grams of carbohydrate; differentiate carbohydrate used to treat a hypoglycemic episode versus appropriate carbohydrate intake to prevent hypoglycemia; added fat may retard and then prolong acute hypoglycemic episode; explain to patient that overtreating low BG can lead to hyperglycemia and weight gain
- Validate patient glucose meter by comparing with institution-calibrated glucose meter
- In unresponsive people with diabetes experiencing hypoglycemic event, follow institution policy regarding glucagon injection or intravenous administration of dextrose

Abbreviation: BG, blood glucose.

Table 7 • Preexercise Hyperglycemia Care for Patients With Type 1 Diabetes

Preexercise	Plan of Care	Intervention
Avoid exercise: If fasting BG is 300 mg/dL or higher and/or ketosis is present • A person with type 1 diabetes who is deprived of insulin for 12 to 48 hour can become ketotic[2]; exercise can aggravate the hyperglycemia and ketosis • Vigorous activity is not recommended in the presence of ketosis; it is not necessary to postpone exercise based simply on hyperglycemia if urine, blood ketones, or both are normal[12]	1. With repeated BG levels of 300 mg/dL or higher, with or without ketones, obtain BG goals and medication adjustments from the physician for planning treatment, and/or interventions needed for an exercise session 2. Help patient determine possible causes of increased BG • Check medication compliance • Insulin pump malfunction • Signs or symptoms of an infection or dehydration	• Obtain individualized BG range for patient if warranted; it would be useful to have physician order for instructions regarding ketone testing • If fasting BG or postprandial BG continues to be elevated, consider an adjustment in insulin dosing; refer patient to physician, CDE, or both for further intervention • Assess patient knowledge and proficiency in following prescribed dosing Check medication and test strip expiration dates • Follow instructions given for checking pump operation • Patient should postpone exercise and followup with physician

Abbreviations: BG, blood glucose; CDE, certified diabetes educator.

β-blockers in these patients is attributable to inhibition of the sympathetic response to hypoglycemia (release of epinephrine and pancreatic release of glucagon) that may occur, resulting in the patient being unable to recognize when BG is too low.[37-39] However, the current consensus is that β-blocker use is not associated with an increased risk of hypoglycemia,[40] and thus, β-blockers are an appropriate treatment for patients with DM who also have cardiovascular disease. Third-generation β-blockers such as carvedilol, have unique properties,

Table 8 • Preexercise Hyperglycemia Care for Patients With Type 2 Diabetes

Preexercise	Plan of Care	Intervention
• Patients with type 2 diabetes should exercise with caution if BG is 300 mg/dL or higher • Routine testing of ketones is not indicated in patients with type 2 diabetes unless they are instructed to do so by their physician	1. With repeated BG levels of 300 mg/dL or higher, obtain BG goals from the physician for planning treatment, interventions, or both needed for an exercise session 2. Help patient determine possible causes of increased BC • Medication compliance • Signs/symptoms of an infection • Dehydration	• Obtain individualized BG range for patient if warranted • If fasting BG or postprandial BG continues to be elevated, consider an adjustment in medications; refer patient to physician, CDE, or both for further intervention • Assess patient knowledge and proficiency in following prescribed dosing • Check medication and test strip expiration dates • Patient should postpone exercise and followup with physician • If elevated BG is caused by timing of meal and patient is asymptomatic, advise exercise with caution; in the absence of very severe insulin deficiency, exercise may decrease the BG level • BG can be evaluated during exercise to make sure it is not increasing; if BG increases, exercise may need to be stopped until patient is within goal range • If hyperglycemic hyperosmolar state is suspected, contact physician immediately

Abbreviations: BG, blood glucose; CDE, certified diabetes educator.

Table 9 • Postexercise Hyperglycemia Care

Postexercise	Plan of Care	Intervention
• Patients with diabetes may have an increase in BG values after exercise if undertreated or if physical activity is performed at intense aerobic levels; this results from an increased catecholamine response to this level of exertion, resulting in an exaggerated release of glucose for fuel; hyperglycemia may last for several hours before BG returns to desired levels[28] • In some patients, the BG supply can exceed demand; this can be seen after intense physical activity such as weight lifting; this response does not erase other fitness benefits, but the individual may feel discouraged or have concerns about doing harm	• Assess patient and extenuating circumstances (consuming a meal just before exercise)	• Instruct the patient to continue monitoring and follow usual treatment guidelines for high BG. • If significant hyperglycemia remains or if the patient is symptomatic, the physician should be contacted

Abbreviation: BG, blood glucose.

Table 10 • Summary of Recommendations/Key Points

Goal	One of the key recommendations for patients with type 1 and type 2 DM is optimal BG control; this has been shown to decrease the incidence of microvascular complications related to DM[20]
Cardiopulmonary rehabilitation	Regular exercise helps maintain appropriate BG levels and is a class I indication in the management of patients with DM[2]
	The cardiopulmonary rehabilitation setting represents an excellent opportunity for health care providers to monitor and manage DM because of the frequent contact and close relationship that personnel and patients usually develop
	Aerobic and strength training exercise may trigger hypoglycemia in people with diabetes, particularly in those with tight BG control; this provides positive feedback regarding the effects of exercise on glycemic control
	Education and guidance are provided to patients to identify risks for hypoglycemia and hyperglycemia and appropriately treat hypoglycemia to avoid unnecessary caloric intake and weight gain[30,32]
Complications	Diabetes is a major risk factor for cardiovascular disease; people with diabetes are 2 to 4 times more likely to have cardiovascular disease than people without DM; in addition, cardiovascular disease in people with diabetes occurs at an earlier age and the lesions are more diffuse; people with diabetes have a high prevalence of hypertension (about 50%) and dyslipidemia, which contribute to their increased cardiovascular disease risk
	People with diabetes, particularly of long duration, are susceptible to autonomic neuropathy and are less likely to have symptoms, for example, angina while experiencing myocardial ischemia; therefore, exercise training tailored by the recognition of symptoms of myocardial ischemia is not straightforward in these patients; indeed, some patients can have a large area of ischemic myocardium before having any chest discomfort or angina equivalent
	Some people with diabetes may have developed long-term complications that make cardiopulmonary rehabilitation more challenging; examples include blindness, nephropathy, peripheral neuropathy with decreased sensation, peripheral vascular disease with significant claudication or digit/limb amputation, and cardiac autonomic neuropathy, characterized by resting tachycardia, inability to increase the heart rate in response to exercise, and orthostatic (postural) hypotension[33,35,36]

Abbreviations: BG, blood glucose; DM, diabetes mellitus.

Table 11 • Cardiopulmonary Rehabilitation Considerations for Diabetes Medications[a,b]

Class	Medications (Trade Names)	Mechanism of Action	CPR Consideration
Biguanides	Metformin (Glucophage, Glucophage XL)	Suppresses excess hepatic glucose production	Risk of hypoglycemia is neutral; risk of GI upset is moderate
Sulfonylureas	Glyburide (Glynase, Diabeta, Micronase); glipizide (Glucotrol, Glucotrol XL); glimepiride (Amaryl)	Stimulates second-phase insulin secretion from the pancreas after meal ingestion	Risk of hypoglycemia is moderate; plan to prevent and manage hypoglycemia
Meglitinides	Nateglinide (Starlix); repaglinide (Prandin)	Rapidly stimulates second-phase insulin secretion from the pancreas; requires dosing with each meal	Risk of hypoglycemia is mild; plan to prevent and manage hypoglycemia
Thiazolidinediones	Pioglitazone (Actos); rosiglitazone (Avandia)	Increases insulin sensitivity in the skeletal muscle, adipose tissue, and liver	Risk of hypoglycemia is neutral, contraindicated in class III-IV heart failure
α-Glucosidase inhibitors	Acarbose (Precose); miglitol (Glyset)	Inhibits absorption of complex carbohydrates from the small intestine	Risk of hypoglycemia is neutral, (if hypoglycemia is present it must be treated with dextrose); risk of GI upset is moderate
GLP-1 receptor agonists	Exenatide (Byetta); liraglutide (Victoza)	Causes glucose-dependent stimulation of insulin secretion and suppression of glucagon secretion	Risk of hypoglycemia is neutral; risk of GI upset is moderate
DPP-4 inhibitors	Sitagliptin (Januvia); saxagliptin (Onglyza)	Inhibits degradation of incretin hormones (GLP-1 and GIP) by DPP-4 enzyme	Risk of hypoglycemia is neutral
Amylin mimetic	Pramlintide (Symlin)	Synthetic analogue of β-cell hormone, amylin; lowers plasma glucagon, delays gastric emptying, promotes satiety	Risk of hypoglycemia is neutral; risk of GI upset is moderate
Bile acid sequestrants	Colesevelam (Welchol)	Treats hypercholesterolemia; also reduces BG in type 2 DM	Risk of hypoglycemia is neutral; risk of GI upset is moderate
Insulin	See Table 12	Injected; exogenous insulin replaces deficiency of naturally occurring hormone	Risk of hypoglycemia is moderate to severe; plan to prevent and manage hypoglycemia

Abbreviations: BG, blood glucose; CPR, cardiopulmonary rehabilitation; DM, diabetes mellitus; DPP, dipeptidyl peptidase; GI, gastrointestinal; GIP, gastric inhibitory peptide; GLP, glucagon-like peptide.
[a]Based on information from Rodbard et al.[31]
[b]Clinicians should be aware that many patients are given a combination of drugs to treat their diabetes. While each of the drugs may have a low risk for hypoglycemia when given alone, combining the drugs can significantly increase the risk of hypoglycemia.

including α_1-blockade and have been shown to lower insulin resistance, improve glycemic control, and vasodilate resistance arterioles.[37] It is recommended that β-blockade, in conjunction with angiotensin-converting enzyme inhibition and aldosterone antagonism, be standard therapy for all patients with DM and heart failure, and that eligible patients are treated with these evidence-based life-prolonging therapies.[41]

Nutritional Considerations

Along with physical activity, primary emphasis should be placed on implementation of nutrition-focused lifestyle modifications, which improve glycemic control and enhance management of blood pressure and lipid abnormalities. This section includes recommendations from a 2007 joint scientific statement regarding nutrition and lifestyle interventions from the ADA and American Heart Association (Table 13).[42]

Medical nutrition therapy (MNT) for patients with diabetes should be individualized on the basis of patient health needs, individual preferences, and willingness to make lifestyle changes. If possible, MNT should be provided by a registered dietitian or CDE familiar with the components of MNT for diabetes.[2] There is no optimal

Table 12 • Insulin Profiles[a]

Insulin Preparation	Onset of Action	Peak	Duration of Action
Aspart (NovoLog); lispro (Humalog); glulisine (Apidra)	About 5-15 min	1-2 h	4-6 h
Human regular insulin (Humulin R, Novolin R)	30-60 min	2-4 h	6-8 h
Human NPH (Humulin N, Novolin N)	2-4 h	4-10 h	12-20 h
Detemir (Levemir)	1-2 h	Relatively flat	Up to 24 h
Glargine (Lantus)	1-2 h	Flat	Up to 24 h
Mixed insulins			
Novolin 70/30	30-60 min	Varies	10-16 h
Humulin 70/30	30-60 min	Varies	10-16 h
Novolog 70/30	5-15 min	Varies	10-16 h
Humalog 75/25	10-15 min	Varies	10-16 h

[a]Based on information from Rodbard et al[31]

percentage of fat, protein, or carbohydrate for people with diabetes and percentages should be individualized to meet metabolic goals. Regardless of the macronutrient mix, total caloric intake must be appropriate for weight management goals. The use of monounsaturated fats in the diet is recommended along with reduction of the intake of saturated fats, trans fat, and cholesterol. Individual protein needs will vary on the basis of body size, degree of metabolic control, and stage of life, but research supports an intake between 16% and 20% of total calories for those with diabetes.

For carbohydrates, the Dietary Reference Intakes[43,44] recommends 130 g per day as a minimum requirement because the brain and central nervous system have an absolute requirement for glucose as an energy source. In addition, extensive carbohydrate deprivation could have deleterious effects on health and well-being.[44] However, it should be recognized that all carbohydrate is digested into glucose and therefore, can raise BG levels. For weight loss, the ADA recommends either low-carbohydrate or low-fat, calorie-restricted diets may be effective in the short-term (up to 1 year). More research is needed to determine if these diets facilitate sustained weight loss and glycemic control over a longer period of time.[42]

It is no longer recommended that people with diabetes avoid all sucrose (table sugar) or other simple sugars. Instead, patients are advised to identify all food sources of carbohydrate, be cognizant of portion sizes eaten, "count their carbohydrate grams or exchanges," and learn how to interpret the nutrition information on food labels. Diabetes professionals recommend spacing carbohydrate intake throughout the day in approximately 3 meals, including 45 to 60 g of carbohydrates per meal, and 2 to 3 snacks, including 15 to 30 g of carbohydrates per snack. Day to day consistent carbohydrate intake may help improve glycemic control.

The Dietary Approaches to Stop Hypertension (DASH) diet is a simple heart-healthy eating plan with emphasis on sodium reduction and weight control.[45] The DASH diet meets the guidelines discussed here for fat intake, protein intake, limited added sugars, reduced sodium, and controlled carbohydrate intake. An additional option is the Therapeutic Lifestyle Changes (TLC) diet,[46] particularly for patients with long-standing DM,

Table 13 • Primary Prevention of Cardiovascular Disease in Patients With Diabetes Mellitus: American Diabetes Association and American Heart Association Goals for Lifestyle and Dietary Treatment[a]

- Calorie reduction with physical activity sufficient to produce a 7% to 10% weight loss
- Low-density lipoprotein cholesterol levels less than 100 mg/dL or less than 70 mg/dL in very high-risk patients
- High-density lipoprotein cholesterol levels for men higher than 40 mg/dL and women higher than 50 mg/dL
- Triglyceride levels lower than 150 mg/dL
- Hemoglobin A_{1c}—American Diabetes Association target of less than 7% but suggests as close to normal (<6%) as possible without causing significant hypoglycemia in individual patients
- Blood pressure lower than 130/80 mm Hg
- Diabetes self-management education
- Complete smoking cessation
- Aspirin: treatment as primary prevention strategy in men age 50 or older and women age 60 or older

[a]Based on information from Buse et al.[42]

who may have organ damage, for example, kidney.[47] The TLC diet limits protein indirectly, through its recommendation to restrict saturated fats. In the cardiopulmonary rehabilitation setting, if there is not access to a registered dietitian or CDE, these plans are easy to teach and easy for patients to follow.

SUMMARY

In the cardiopulmonary rehabilitation setting, DM presents both staff and patient challenges in dealing with daily exercise progression. The American Association of Cardiovascular and Pulmonary Rehabilitation and American Heart Association have identified management of diabetes as one of the core components of a cardiac rehabilitation program.[16] Programs must develop policies and procedures that reflect the current evidence and the best practices available. Program staff requires the education and support necessary to make informed decisions regarding optimal BG levels before and after exercise, and to identify comorbid conditions that affect the exercise prescription.

Consideration of progression of activity in patients with diabetes, including intensity, duration, and frequency, should be based on exercise adaptation, glycemic response, control of cardiovascular risk factors, and comorbidities. Moderate intensity exercise, for 150 minutes per week, has a beneficial effect on glycemic control. A combination of aerobic and resistance exercise has shown improved insulin sensitivity and A1c-lowering value.[2] The American College of Sports Medicine and the American Diabetes Association have released a joint position statement on exercise and type 2 diabetes. This can be an excellent resource to help modify the exercise prescription.[34]

Access to the integral components of diabetic care and self-management is essential. Treatments and therapies needed to improve glycemic control and reduce the complications of diabetes can be addressed in the setting of cardiopulmonary rehabilitation programs. In addition, a dietitian and the contributions of a certified diabetic educator can provide an additional level of expertise to assist the staff.

The focus of the program staff on behavior change and self-efficacy strongly correlates with the American Association of Diabetes Educators 7 Self-Care Behaviors.[24] Recognizing these similarities, some staff may consider becoming CDE credentialled[48] or board-certified in advanced diabetes management[49] as part of their professional development. The management of patients with diabetes will continue to challenge cardiopulmonary rehabilitation programs. Facing this challenge requires a partnership between patients, physicians, other health care providers, and the rehabilitation staff. Table 10 summarizes the key points and recommendations of this statement.

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