

Clinical Exercise Physiology

Diabetes Mellitus

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Definition

- **Diabetes mellitus**

- A group of metabolic diseases
- Characterized by inability to produce sufficient amounts of insulin or to use it properly
- Result—hyperglycemia

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Definition *(continued)*

- Places affected individuals at risk for:
 - Microvascular diseases
 - Retinopathy
 - Nephropathy
 - Macrovascular diseases
 - Cardiovascular
 - Cerebrovascular
 - Neuropathies
 - Autonomic
 - Peripheral

Scope

- **Afflicts ~26 million in United States**
 - Approximately 25% are undiagnosed
 - Number with diabetes tripled in past 30 yr
 - Estimates of doubling in next 15 to 20 yr
- **A worldwide problem**
- **Reasons for epidemic**
 - Increasing overweight and obesity
 - Increasing sedentary lifestyle
 - Aging of population (baby boomers becoming golden boomers)

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Scope *(continued)*

- **Diabetes-related death rate two times that of age-matched, nondiabetic individuals**
- **Huge associated health care costs, ~\$174 billion annually**

Pathophysiology

- **Diabetes categories**

- **Type 1:** beta-cell destruction leading to insulin deficiency
 - Immune mediated (autoimmune disease)
 - Idiopathic
- **Type 2:** ranges from insulin resistance to insulin deficiency
 - Could include insulin secretion defect, insulin resistance, or both
 - Strong genetic influence
 - 90% to 95% of all diabetes types

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Pathophysiology *(continued)*

– Other types

- Genetic beta-cell function defect
- Genetic insulin action defect
- Diseases of pancreas
- Endocrinopathies
- Drug or chemical induced
- Infections

– Gestational

- Glucose intolerance onset or first recognition with pregnancy

– NOTE: Insulin requirement can occur with any form of diabetes, but its use does not classify the diabetes type.

Pathophysiology *(continued)*

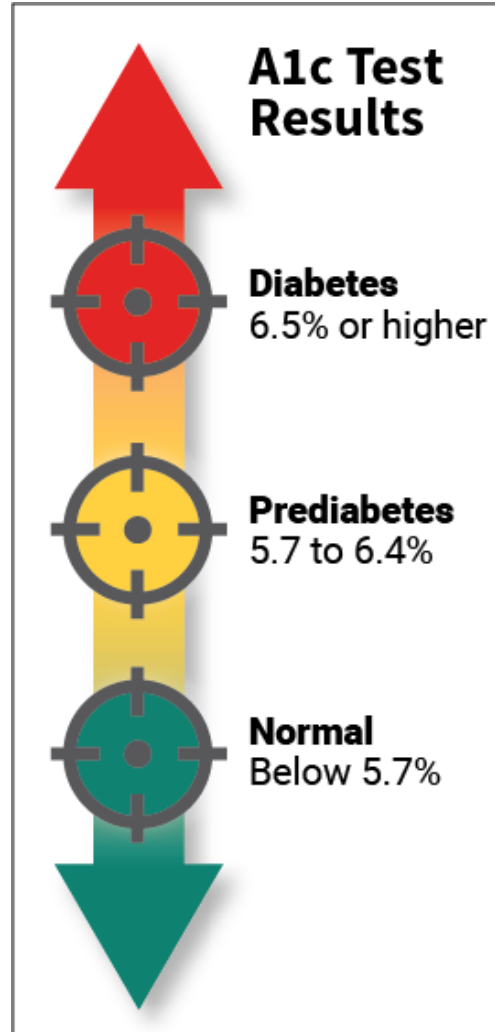


Figure 1

Stages Types	Normoglycemia	Hyperglycemia			
	Normal glucose regulation	Impaired glucose tolerance or impaired fasting glucose	Diabetes mellitus		
			Non-insulin requiring	Insulin requiring for control	Insulin requiring for survival
Type 1 ^a	←				→
Type 2	←			→	
Other specific types ^b	←			→	
Gestational diabetes ^b	←			→	

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Pathophysiology *(continued)*

- **Complications**

- Acute complications

- Hyperglycemia

- Diabetes out of control

- Diabetic ketoacidosis

- Hyperosmolar nonketotic syndrome

- Hypoglycemia

- Too much insulin or selected antidiabetic oral agent

- Too little carbohydrate intake

- Missed meals

- Excessive or poorly planned exercise

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Pathophysiology *(continued)*

–Chronic complications

- Macrovascular
 - Large-vessel disease of coronary arteries, cerebrum, and peripheries
- Microvascular
 - Small-vessel disease of eyes and kidneys
- Neuropathy
 - Affecting both the peripheral and autonomic systems

Clinical Considerations

- **Signs and symptoms**

- Polydipsia (excessive thirst)
- Polyuria (frequent urination)
- Unexplained weight loss
- Infections and cuts that are slow to heal
- Blurry vision
- Fatigue

- **Most common in those with type 1**

- **Less often or never in those with type 2**

- 25% of those with diabetes do not know it

History and Physical Exam

- **Medical history review**

- Acute and chronic complications
- Laboratory values for HbA1c, plasma glucose, lipids, and proteinuria
- Blood pressure
- Self-monitoring blood glucose results
- Body weight and body mass index
- Medication use and timing
- Exercise history
- Nutrition plan
- Other non-diabetes-related health issues

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History and Physical Exam *(continued)*

- **Physical exam focuses on potential diabetes complications:**
 - Elevated resting heart rate
 - Loss of sensation
 - Loss of reflexes (especially lower extremities)
 - Foot sores or ulcers with poor healing
 - Excessive bruising
 - Retinal vascular abnormalities

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Diagnostic Testing

- **ADA recommends diagnostic testing on all those with diabetes and those who:**
 - Are physically inactive
 - Have a first-degree relative with diabetes
 - Are of a high-risk race or ethnicity (e.g., African American, Latino, Native American, Pacific Islander)
 - Are women who delivered a baby weighing more than 9 lb (4 kg) or were diagnosed with gestational diabetes

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Diagnostic Testing *(continued)*

- Have hypertension ($\geq 140/90$ mmHg or on therapy for hypertension)
- Have high-density cholesterol ≤ 35 mg/dl and/or triglycerides ≥ 250 mg/dl
- Have A1c ≥ 5.7 , an impaired fasting glucose or glucose tolerance test
- Are women with polycystic ovarian syndrome
- Have other clinical conditions associated with insulin resistance (e.g., severe obesity, acanthosis nigricans)
- Have a history of CVD
- Are at least 45 years old

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Diagnostic Testing *(continued)*

- **Diabetes diagnostic criteria:**

- A1c $\geq 6.5\%$, or
- Fasting plasma glucose ≥ 126 mg/dl (7.0 mmol/L), or
- Two-hour plasma glucose ≥ 200 mg/dl (11.1 mmol/L) during an oral glucose tolerance test, or
- Classic symptoms of hyperglycemia or hyperglycemic crisis plus a random plasma glucose ≥ 200 mg/dl (11.1 mmol/L). The classic symptoms of diabetes include polyuria, polydipsia, and unexplained weight loss.

- **Each diagnostic test should be repeated for confirmation of results.**

Exercise Testing

- **Cardiovascular exercise testing is indicated for those with one or more of the following:**
 - Age >40 yr, with or without CVD risk factors other than diabetes
 - Age >30 yr and
 - Type 1 or type 2 diabetes of >10 yr
 - Hypertension
 - Cigarette smoking
 - Dyslipidemia
 - Proliferative or preproliferative retinopathy
 - Nephropathy including microalbuminuria
 - Any of the following, regardless of age:
 - Known or suspected CAD, cerebrovascular disease, and/or peripheral artery disease
 - Autonomic neuropathy
 - Advanced nephropathy with renal failure

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Exercise Testing *(continued)*

- **May be beneficial if exercise training intensity is planned to be vigorous (i.e., >60% of peak VO_2)**
- **Resistance and range of motion exercise testing as needed for exercise prescription development**

Treatment

- **Medical nutrition therapy (MNT)**
 - May ultimately focus on large weight loss from a complete meal replacement diet or bariatric surgery
- **Self-monitoring of blood glucose**
- **Diabetes self-management education**
 - Delivered by a certified diabetes educator (can be a clinical exercise physiologist who is certified)

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Treatment *(continued)*

- **Medication**
- **Requires involvement of patient, family members, and health care team (physician [primary care or endocrinologist]), nurse or nurse practitioner, diabetes educator, registered dietitian, clinical exercise physiologist, and a behaviorist)**

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Treatment *(continued)*

- **Oral glucose-lowering medication types**
 - Sulfonylureas (first and second generation)
 - Meglitinides
 - Biguanides
 - Thiazolidinediones
 - Alpha-glucosidase inhibitors
 - Incretins and amylin analogs
 - DPP-4 inhibitors
 - Insulin
 - Rapid acting
 - Short acting
 - Intermediate acting
 - Long acting

(continued)

Treatment *(continued)*

- **Focused on guidelines developed by the American Diabetes Association (ADA)**
- **Provide evidence-based care**
 - Regular HbA1c testing
 - Dilated eye exam
 - Foot exam
 - Blood pressure monitoring
 - Blood lipid assessment
 - Renal function testing
 - Smoking cessation counseling
 - Flu or pneumococcal immunizations
 - Diabetes education
- **Focus should be on the prevention and treatment of abnormal blood glucose before and after exercise**

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Treatment *(continued)*

- **Little risk of hypoglycemia for those controlled by diet or oral glucose-lowering medications**
- **If before exercise:**

Blood glucose	Exercise intensity	Exercise duration	Preexercise CHO consumption	Blood glucose
<100 mg/dl	Low	Short	5-10 g	<100 mg/dl
	Moderate	Moderate	25-45 g	
	Moderate	Long	45 g	
≥100 mg/dl	Low	Short	None	≥100 mg/dl
100 to 180 mg/dl	Moderate	Moderate	15-30 g	100 to 180 mg/dl
	Moderate	Long	30-45 g	

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Treatment *(continued)*

- **If preexercise hyperglycemia (>300 mg/dl):**
 - Check urine for ketones and postpone exercise if moderate to high
 - Allow exercise if ketones are low
 - Make sure patient is well hydrated
- **If postexercise hypoglycemia (<70 mg/dl):**
 - Monitor glucose for several hours postexercise
 - Use CHO to stabilize glucose
 - Suggest frequent postexercise monitoring in future
- **If postexercise hyperglycemia:**
 - More likely in type 1 than type 2
 - Treat as needed to lower glucose to normal range

Exercise Prescription Review

- **Consider:**

- Macrovascular disease—heart and peripheral vasculature
- Peripheral neuropathy
- Autonomic neuropathy—reduced HR, BP, and blood flow redistribution control
- Retinopathy
- Nephropathy

Exercise Recommendations

- **Perform at a time of day most convenient for the patient with respect to ability to assess and control blood glucose**
 - Avoid peak insulin action
 - Avoid late evening if on insulin or oral medications that lower blood glucose and risk hypoglycemia
 - Perform at similar times each day to maintain steady glucose levels

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Exercise Recommendations *(continued)*

- **Goal of 150 min/wk moderate or 60 to 75 min/wk vigorous exercise**
- **Perform low to moderate intensity due to potential cardiovascular disease; increase intensity only if CAD is ruled out**
- **Non-weight-bearing exercise may be necessary for those with peripheral neuropathy or vascular disease**

Physiological Adaptations and Benefits

- **Acute exercise**

- Improves blood glucose values
- Sustains postexercise blood glucose control
- Reduces hepatic glucose production
- Increases skeletal muscle glucose utilization

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Physiological Adaptations and Benefits *(continued)*

- **Chronic exercise (i.e., exercise training)**
 - Improved overall metabolic control (blood glucose, insulin resistance)
 - Blood pressure control and reduced hypertension risk
 - Blood lipid improvements
 - Reduced body fat and increased lean body mass
 - Weight loss and improved weight maintenance
 - Psychological and social well-being
 - Delay or prevention of type 2 diabetes in those at risk

Conclusion

- **Dealing with diabetes requires ongoing special attention.**
- **Exercise training should be encouraged based on its benefits, particularly in controlling cardiovascular disease–related risk factors.**
- **Exercise training requires additional diligence in blood glucose monitoring to avoid the acute effects of hypoglycemia.**
- **Exercise training is an important method to help control blood glucose values.**