

Clinical Exercise Physiology

Diabetes Mellitus

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Diabetes Mellitus

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Presentation Content

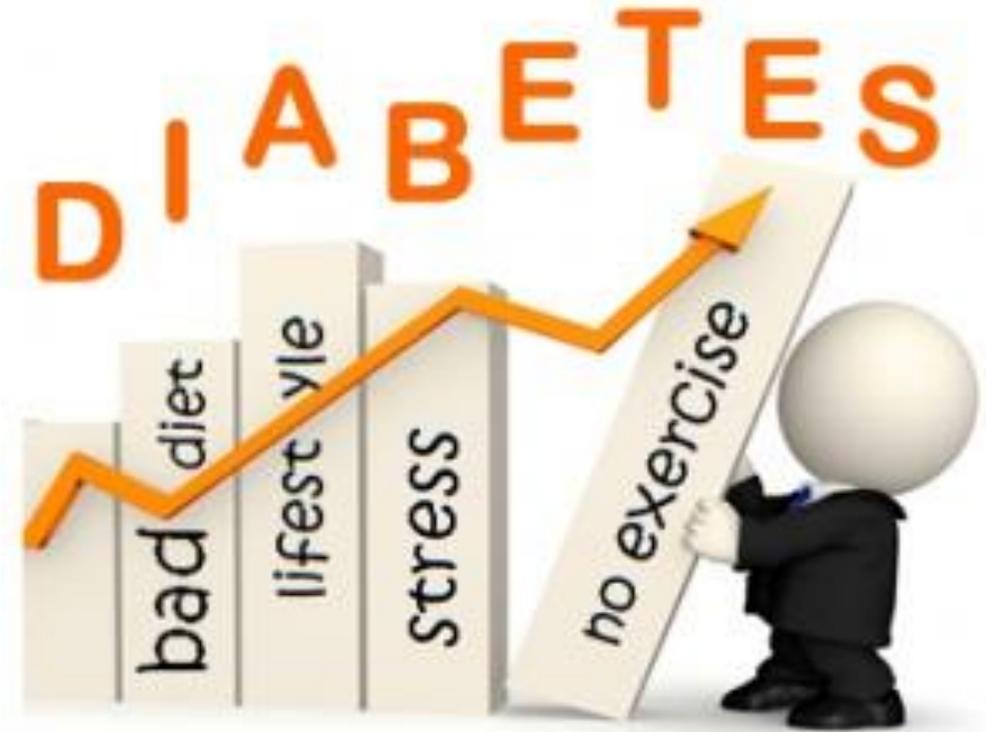
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Definition

- **Diabetes mellitus**

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

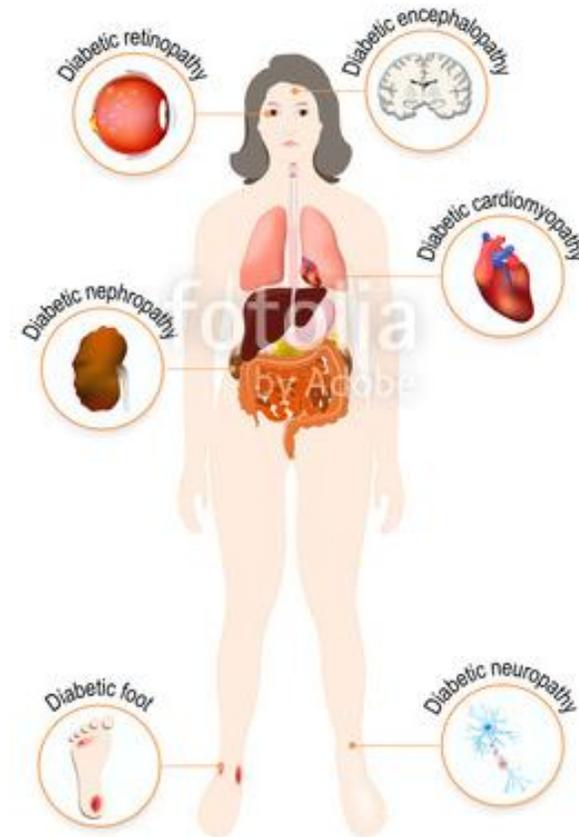
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Definition *(continued)*

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

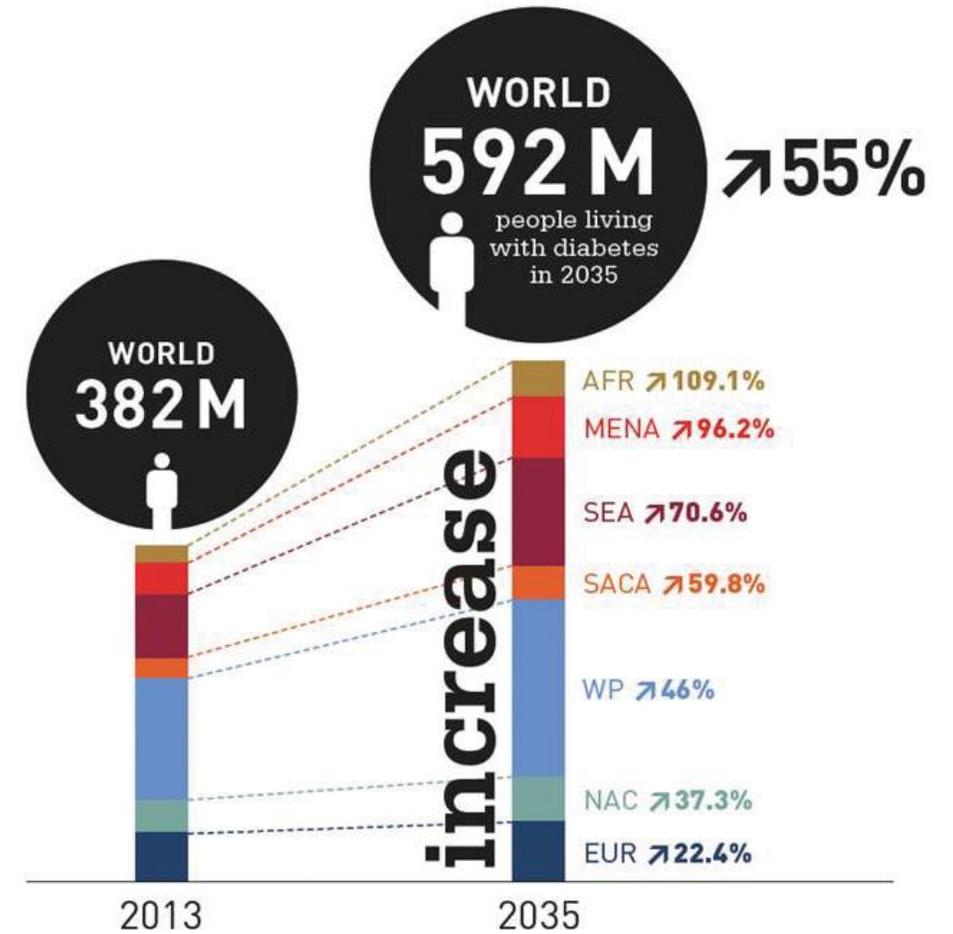
Complications of DIABETES MELLITUS



Epidemiology

- **Afflicts >30 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

(continued)



DIABETES

3.7 MILLION

DEATHS DUE TO DIABETES AND HIGH BLOOD GLUCOSE

1.5 MILLION
DEATHS CAUSED BY DIABETES



2015
one in **11** adults has diabetes

DIABETES IS ON THE RISE

2040
one in **10** adults will have diabetes

388 MILLION
ADULTS HAVE DIABETES



THE GLOBAL PREVALENCE OF DIABETES AMONG ADULTS OVER 18 YEARS OF AGE HAS RISEN FROM 4.7% IN 1980 TO 8.5% IN 2014



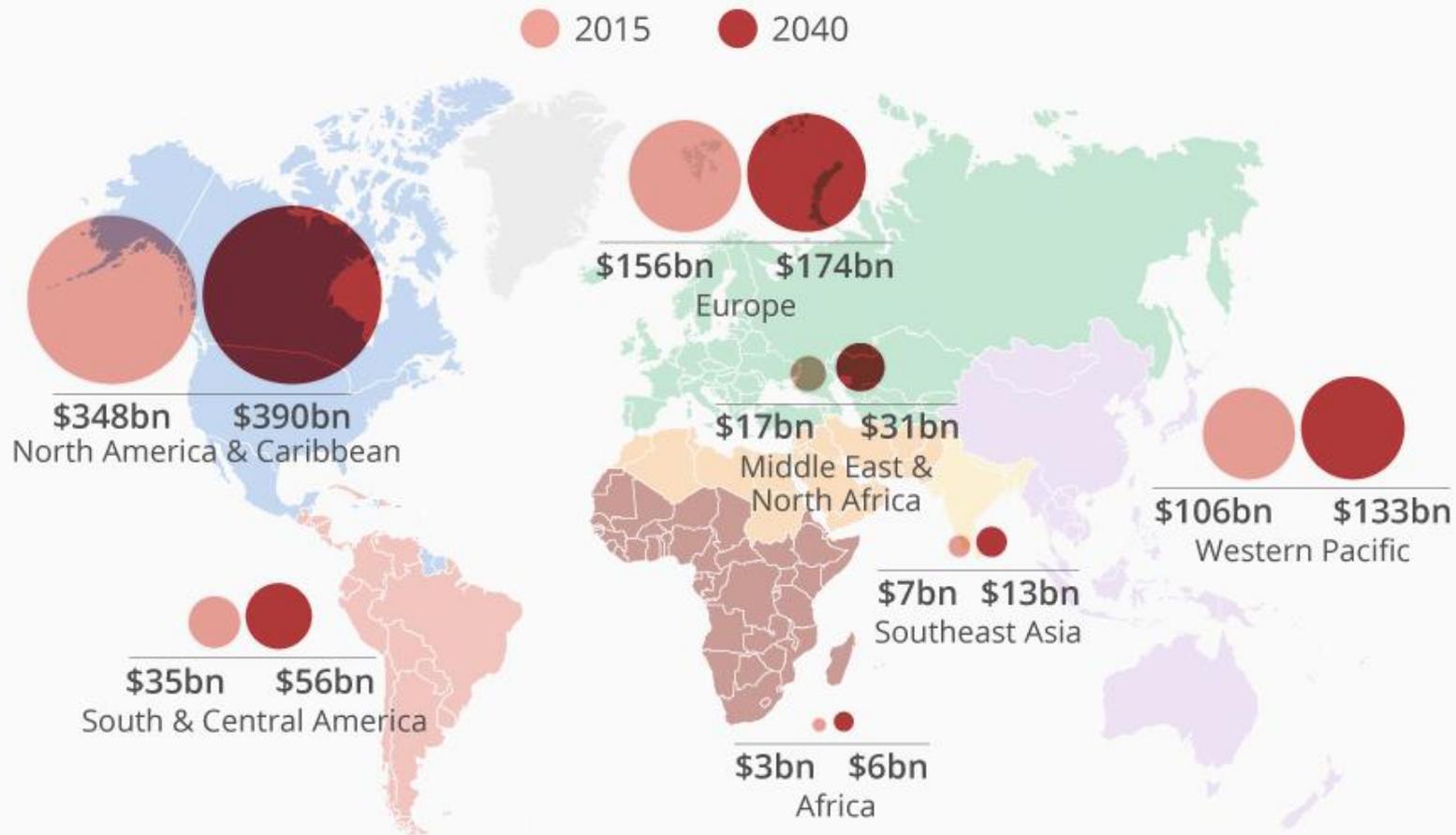
VILLA MEDICA

CLINIC FOR REGENERATIVE MEDICINE

GERMANY-SINCE 1978

The Global Cost Of Diabetes

Worldwide healthcare expenditure due to diabetes in 2015 and 2040, by region*

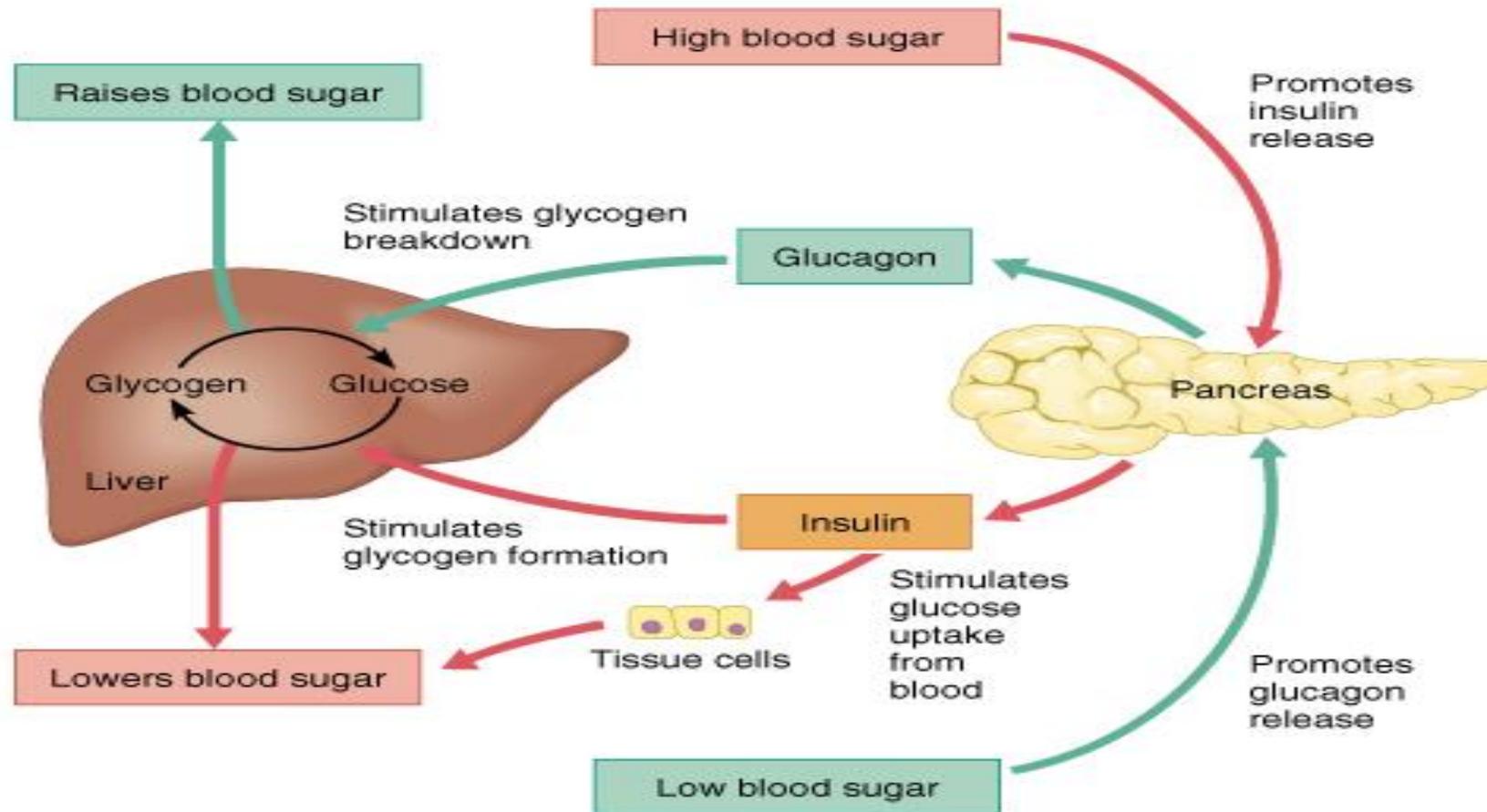


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* 2040 figures are forecasts
Source: International Diabetes Federation

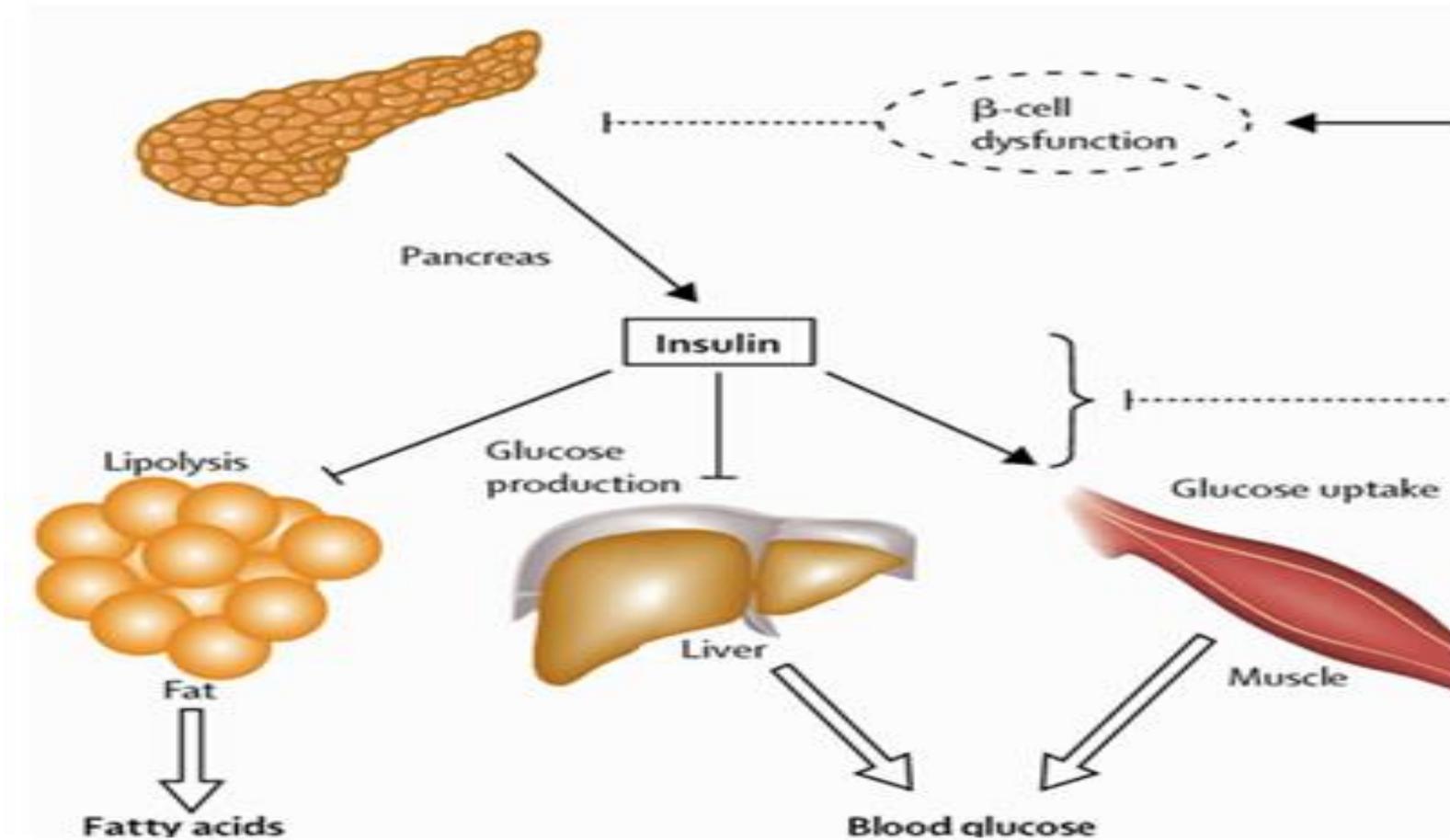
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Blood Glucose Regulation

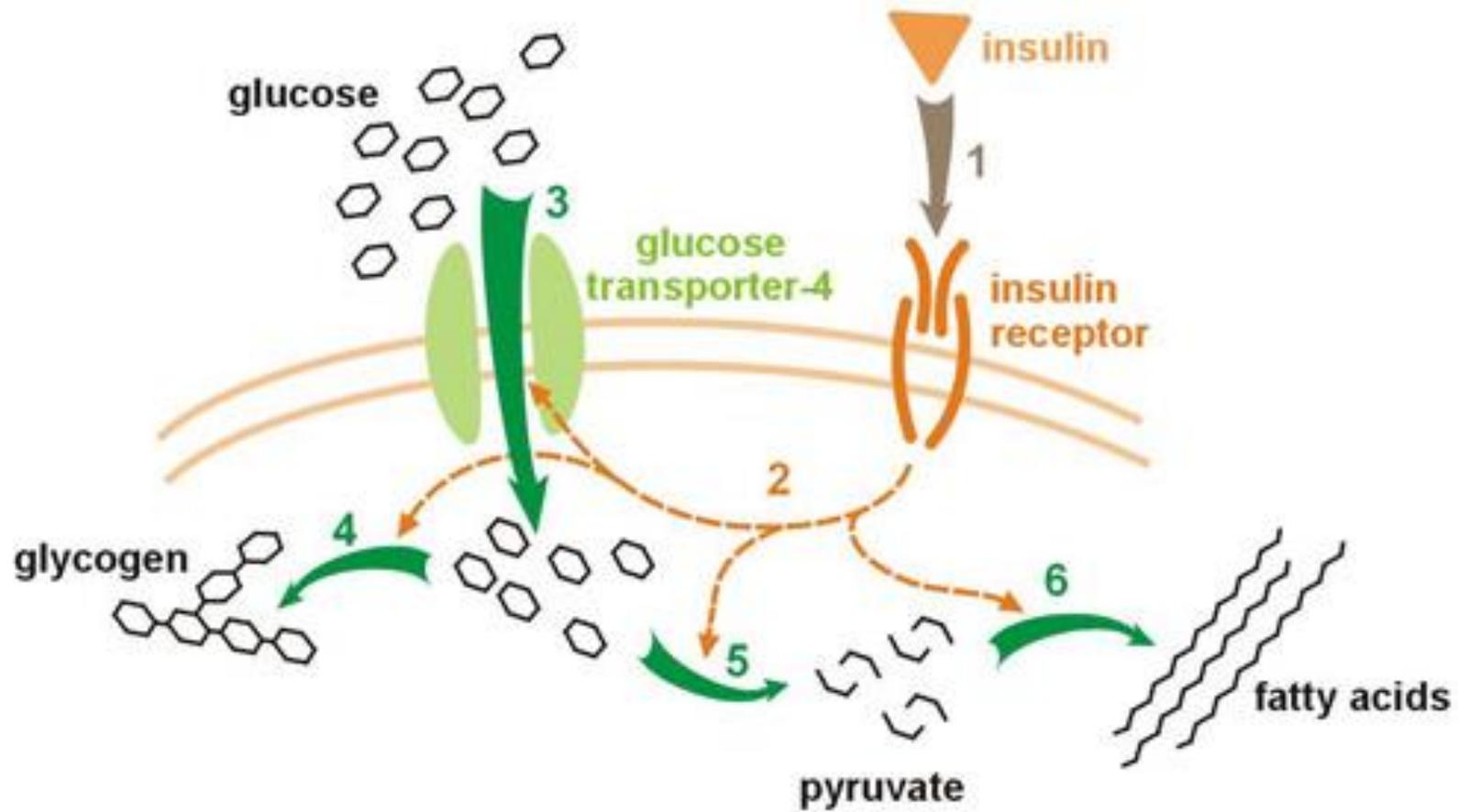


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Insulin Target Tissues



Insulin Action



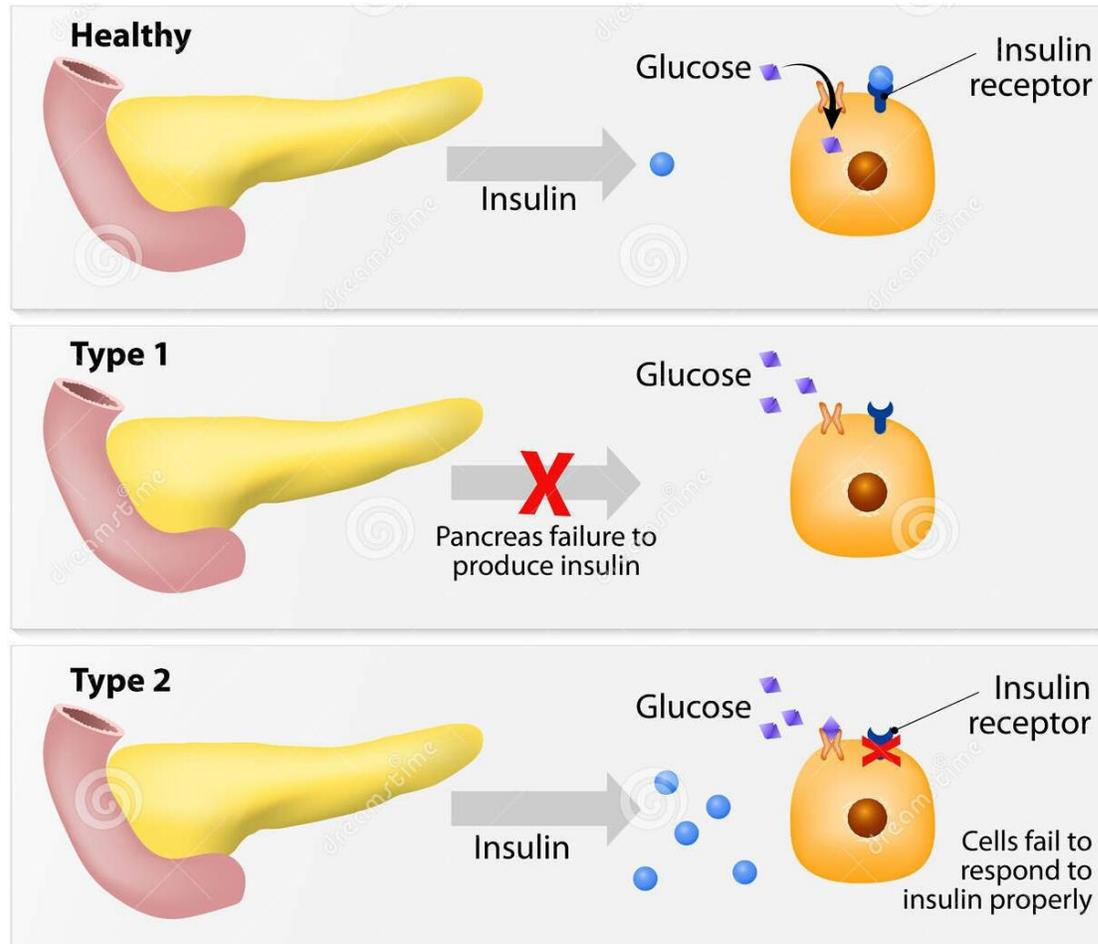
Pathophysiology

- **Diabetes categories**

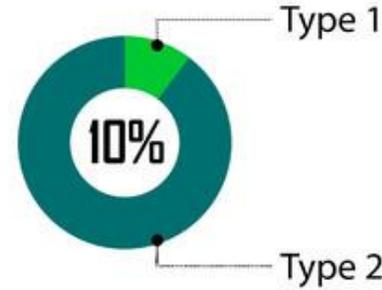
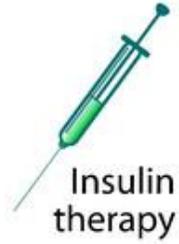
- **Type 1:** beta-cell destruction leading to insulin deficiency
 - Immune mediated (autoimmune disease)
 - Idiopathic
 - Usually occurs in childhood and adolescence
- **Type 2:** ranges from insulin resistance to insulin deficiency
 - Could include insulin secretion defect, insulin resistance, or both
 - Usually occurs after the age of 40yrs
 - Strong genetic influence
 - 90% to 95% of all diabetes types

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Pathophysiology



DIABETES MELLITUS type 1



Risk

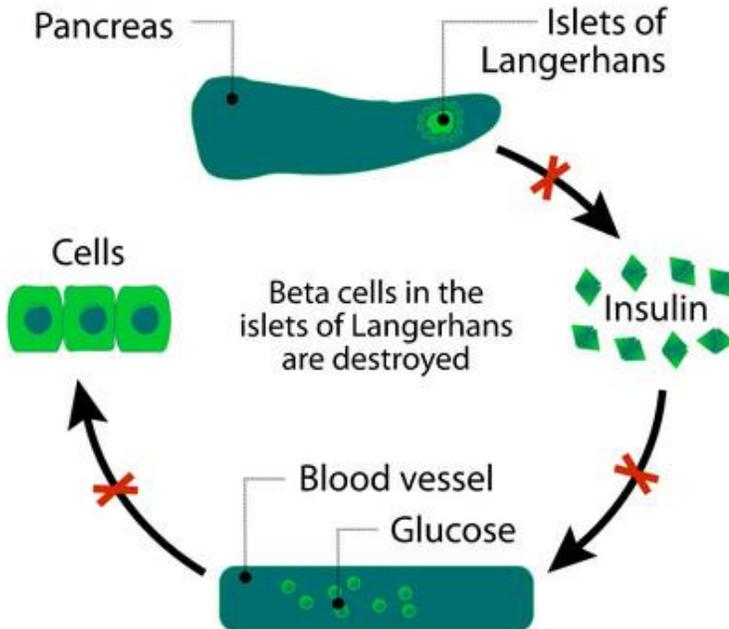


Genetic susceptibility



Children under 14 years

Cause



Signs and symptoms



High blood sugar



Weight loss



Increased hunger



Increased thirst

Complications



Kidney failure



Cardiovascular disease

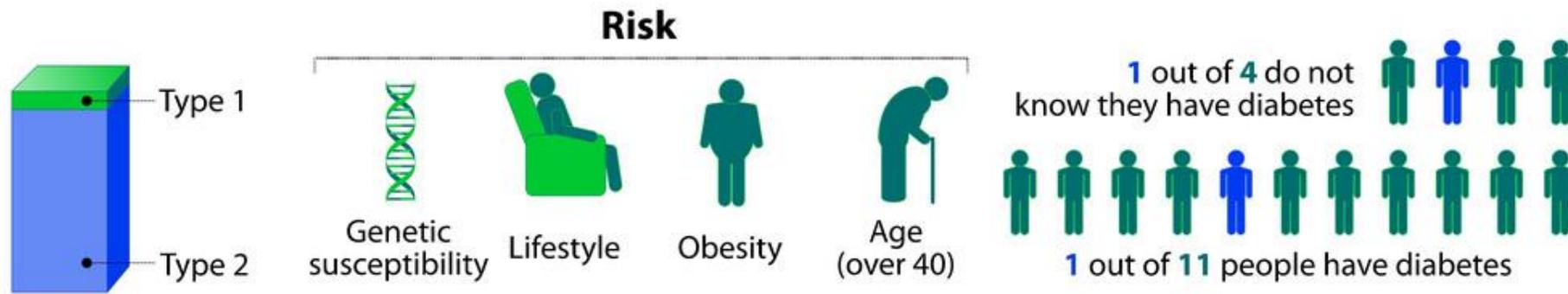


Diabetic retinopathy

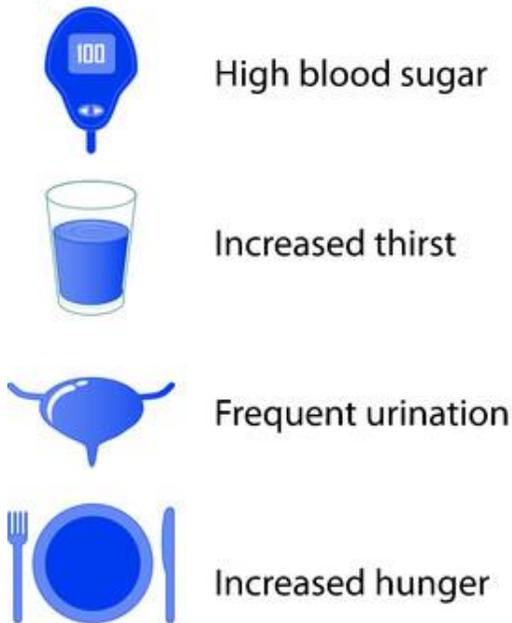


Foot ulcers

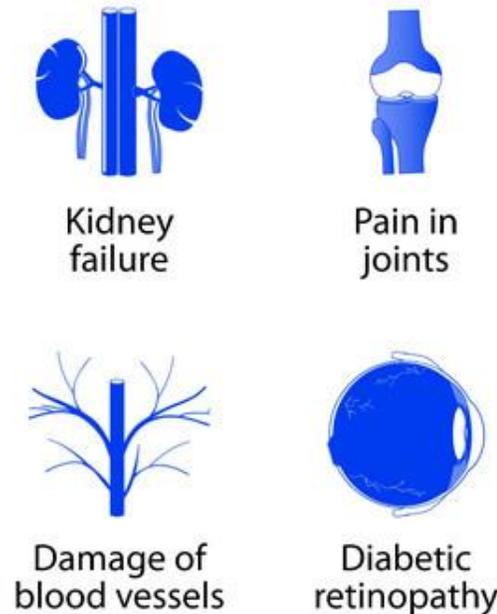
DIABETES MELLITUS type 2



Signs and symptoms



Complications



Diabetes management



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.

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**

- Occurring factors

- Too much insulin or selected antidiabetic oral agent

- Too little carbohydrate intake

- Missed meals

- Excessive or poorly planned exercise

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

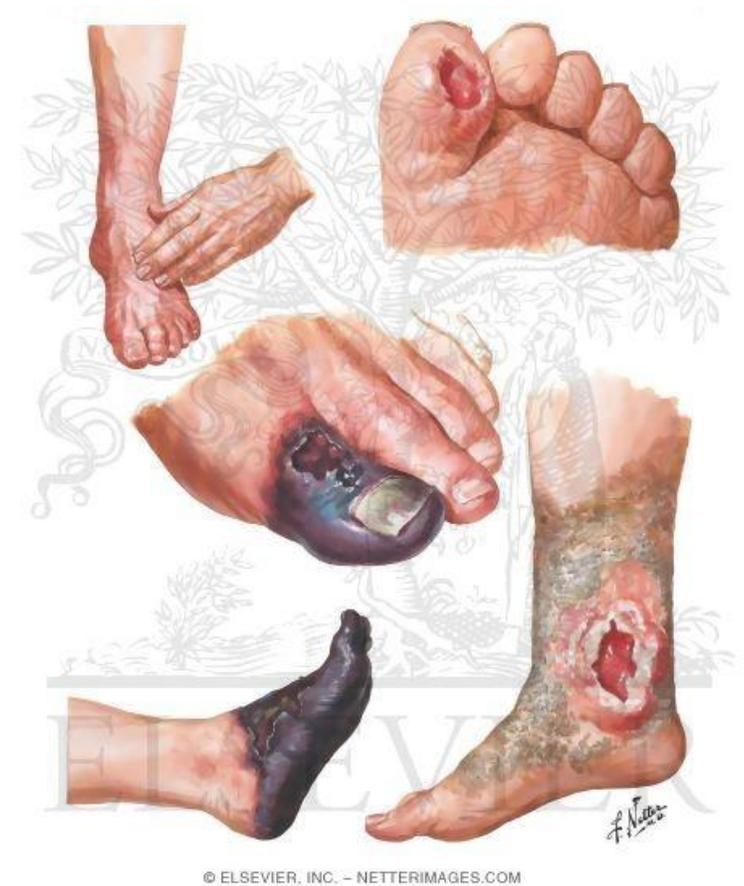
Clinical Considerations

- **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**

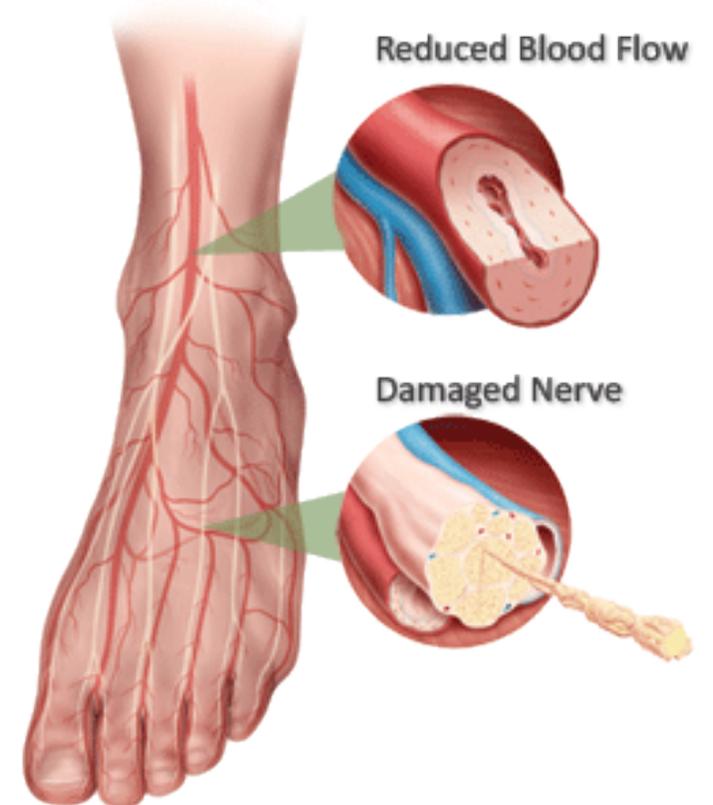


History and Physical Exam

- **Medical history review for exercise clearance**

- 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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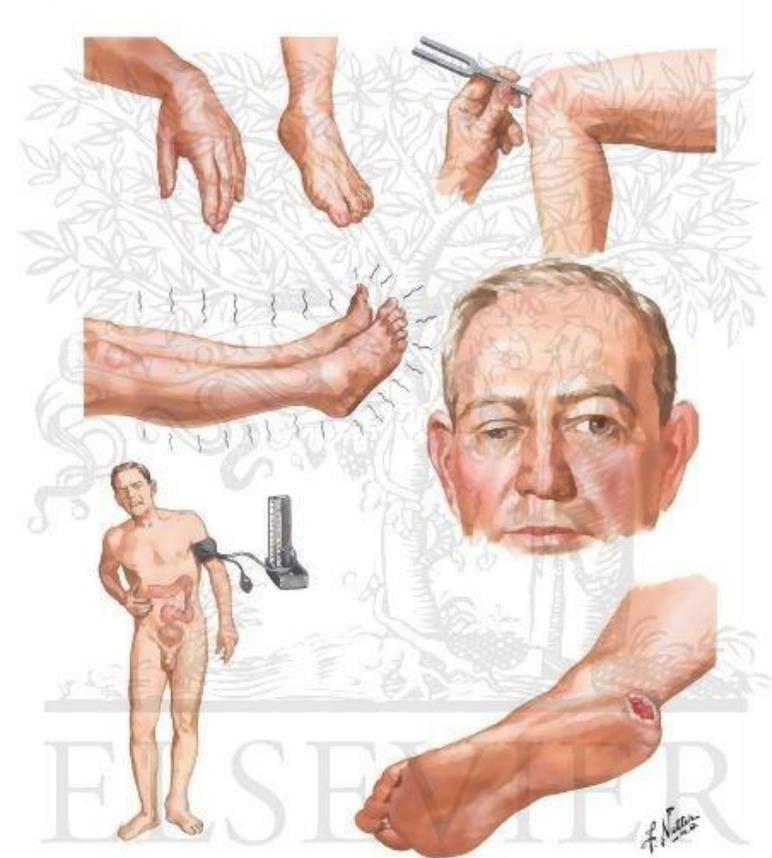


History and Physical Exam *(continued)*

- **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

(continued)



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Diagnostic Testing

- **ADA recommends diagnostic testing on all those with high diabetes risk factors:**
 - **Physically inactive**
 - **First-degree relative** with diabetes
 - **High-risk race or ethnicity** (e.g., African American, Latino, Native American, Pacific Islander)
 - 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)*

- **Hypertension** ($\geq 140/90$ mmHg or on therapy for hypertension)
- **High-density cholesterol** ≤ 35 mg/dl and/or triglycerides ≥ 250 mg/dl
- **A1c $\geq 5.7\%$** , an impaired fasting glucose or glucose tolerance test
- Women with **polycystic ovarian syndrome**
- Have other clinical conditions associated with **insulin resistance**
- Have a **history of CVD**
- Are at least **45 years old** (in the absence of the above criteria)

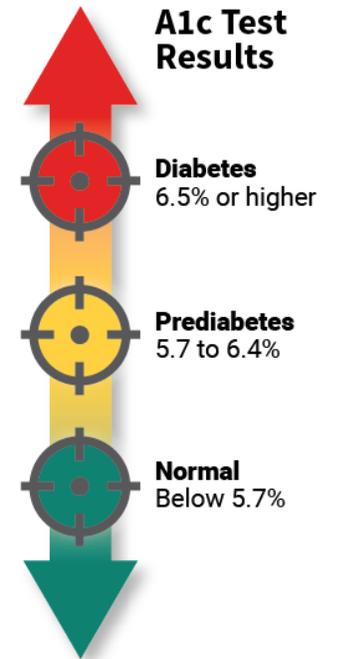
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Diagnostic Testing *(continued)*

- **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 (OGTT), or
- Classic symptoms of hyperglycemia (polyuria, polydipsia, and unexplained weight loss) or hyperglycemic crisis plus a random plasma glucose ≥ 200 mg/dl (11.1 mmol/L).

- **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

(continued)

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.



Exercise Testing Review

Test type	Mode	Protocol specifics	Clinical measures	Clinical implications	Special considerations
Cardiovascular	Treadmill Ergometer (leg or arm)	Low level for many (≤ 2 METs per stage or 20 W/min increases in work rate)	Peak $\dot{V}O_2$ or estimated METs Heart rate and blood pressure responses 12-lead ECG	Watch for ischemia and arrhythmias because these are often undiagnosed and patients are at high risk for heart disease.	Chest pain due to myocardial ischemia may not be perceived in those with neuropathy (also may blunt peak HR achieved). Patients with peripheral vascular disease probably should use the cycle ergometer mode. Consider testing blood glucose before exercise test to reduce the risk of hypoglycemia.
Resistance	Machine weights Isokinetic dynamometer	1RM or indirect 1RM method	Strength and power		1RM may not be recommended in those with severe disease and those who are sedentary. Those with retinopathy most typically should not perform resistance training.
Range of motion	Sit-and-reach Goniometry		Major muscle groups range of motion		Patients should not hold breath; any exercise may result in excessive blood pressure response.

Data from Lohman 1992.

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)

(continued)

Treatment *(continued)*

- **Medication**

- Oral Glucose – Lowering Medications
 - Incretins and Amylin
 - Insulin Rapid Acting, Short Acting, Intermediate Acting, Long Acting.
- 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)

(continued)

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**

(continued)

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
	Moderate	Moderate	15-30 g	
	Moderate	Long	30-45 g	

(continued)

Exercise Considerations

- **If preexercise hyperglycemia (>300 mg/dl):**
 - Check urine for ketones and postpone exercise if moderate to high intensity
 - 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

- Exercise must be prescribed with careful consideration given to **risks** and **benefits**.
- **Consider:**
 - Macrovascular disease (coronary and peripheral vasculature)
 - Peripheral neuropathy (loss of protective sensation in the feet and legs)
 - Autonomic neuropathy (abnormal HR, BP, and blood flow redistribution)
 - Retinopathy (avoid high-intensity aerobic and resistance training with large increases in systolic blood pressure)
 - Nephropathy (strenuous exercises should likely be discouraged)

Exercise Recommendations

Training method	Mode	Intensity	Frequency	Duration	Progression	Goals
Aerobic	Walking, cycling, swimming	40% to 60% of VO ₂ reserve	3-7 times week No more than two consecutive days between bouts of activity	Minimum of 150 min/wk of moderate activity (30 min, 5 d/wk) or 60 to 75 min of vigorous activity (20 min, 3 d/ wk) and up to ≥ 300 min/ wk	Rate of progression depends on many factors including baseline fitness, age, weight, health status, and individual goals. Gradual progression of both intensity and volume is recommended.	Patient dependent Energy expenditure of 1,000 to 2,000 kcal/wk
Resistance	Free weights, machines, elastic bands 5 to 10 exercises involving the major muscle groups	Moderate at 50% of 1RM or vigorous at 75% to 80% of 1RM	2-3 times / week Never on consecutive days	8 to 15 repetitions per set, 1 -3 sets per type of specific exercise	As tolerated. Increase resistance first, followed by a greater number of sets, and then increased training frequency.	
Range of Motion	Static stretching		Along with resistance training	10 to 30 s per exercise of each muscle group	As tolerated. May increase range of stretch as long as patient does not complain of pain (acute or chronic).	

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

(continued)

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

Cardiorespiratory endurance	Skeletal muscle strength	Skeletal muscle endurance	Flexibility	Body composition
<p>Associated with a lower risk of all-cause mortality and cardiovascular mortality.</p> <p>Prevention or delay of type 2 diabetes.</p> <p>Improves insulin action and fat oxidation and storage in muscle, and can improve blood glucose control.</p> <p>Exercise intensity affects blood glucose control to a greater extent than exercise volume.</p> <p>May result in a small reduction in LDL cholesterol.</p> <p>May result in a small reduction in systolic blood pressure, but reductions in diastolic blood pressure are less common.</p>	<p>Improves insulin action and fat oxidation and storage in muscle, and can improve blood glucose control.</p>	<p>Improves insulin action and fat oxidation and storage in muscle, and can improve blood glucose control.</p>	<p>Flexibility training combined with resistance training can increase range of motion.</p> <p>Flexibility training has not been shown to reduce risk of injury.</p>	<p>Helps produce and maintain weight loss.</p> <p>Combined weight loss and exercise may be more effective with respect to lipids than aerobic training alone.</p>

Physiological Adaptations and Benefits

- **Acute exercise**

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

(continued)



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.