Diabetes Mellitus

Arden Gregory RN, PhD, CDDN
Statewide Nursing Coordinator

Course Objectives

- Define/Characterize Diabetes Mellitus (DM)
- Review the incidence of DM
- Examine carbohydrate/glucose digestion, absorption & metabolism
- Analyze the hormones/chemicals involved in glucose digestion, absorption & metabolism
- Examine insulin functions in detail

Course Objectives

- Review DM risk factors
- Consider possible causes of DM
- Examine DM pathology by DM type
- List and study Sx of DM & Tx complications
- Examine DM complications
- Review DM Tx Modalities

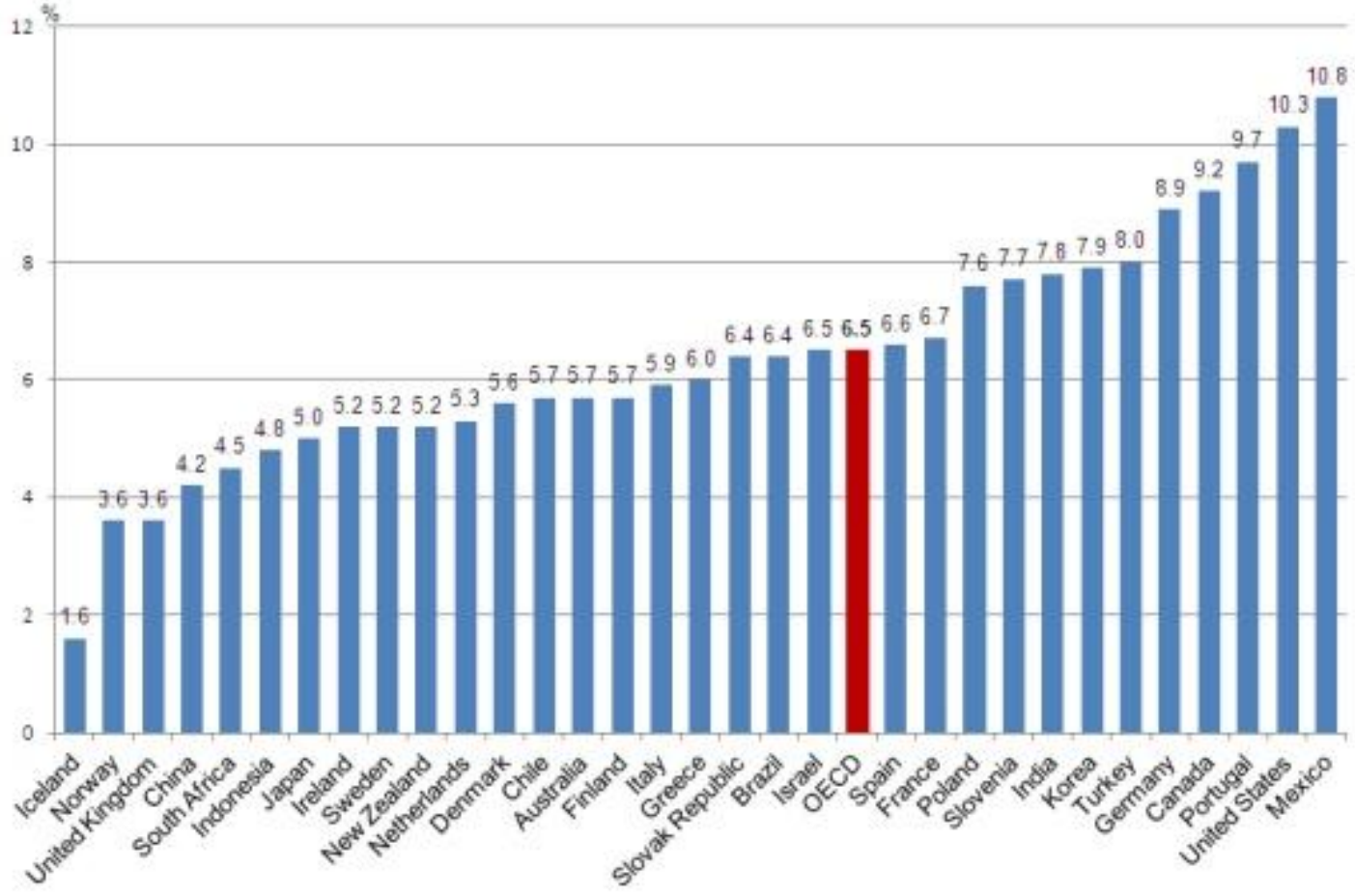
Definition

- A complex group of metabolic diseases in which a person has elevated blood sugar concentration (hyperglycemia of ≥ 126 mg/dl or HbA_{1c} ≥ 6.5)

Who, When, What (3)

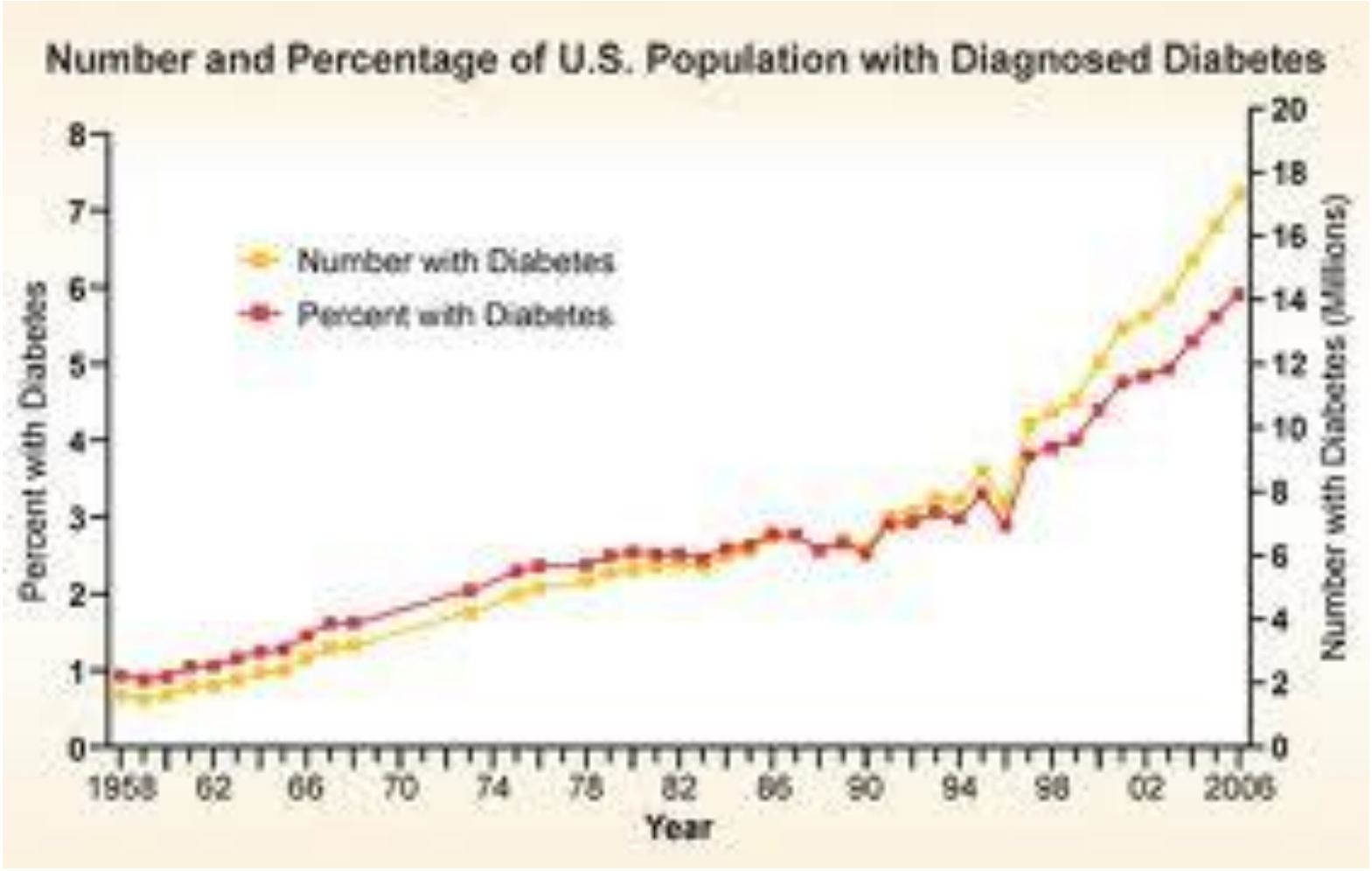
STATISTICS

Prevalence of Diabetes by Country



Epidemiology - World

- In 2011, 366 million had DM. Estimated that ½ (183 million) are undiagnosed
- DM caused 4.6 million deaths in 2011
- Prediction: by 2030, 552 million will have DM.


Number and Percentage of U.S. Population with Diagnosed Diabetes
Number with Diabetes
Percent with Diabetes
Percent with Diabetes
Number with Diabetes (Millions)
Year
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10
12
14
16
18
20
1958
62
66
70
74
78
82
86
90
94
98
02
2006

Epidemiology – U.S. (1)

- 25.8 million = 8.3% of population (2011)
- 18.8 million diagnosed; 7.0 million undiagnosed (2011)
- Prediabetes affects 35% of adults 20+

Epidemiology – U.S. (2)

- Age (2011)
  - 215,000 < 20 years (2.6%) (about 1 in 400)
  - 10.9 million > 65 (26.9%) (Types 1 & 2)
- Gender
  - Males: 13.0 million or 11.8% of pop. age 20 or older
  - Females: 12.6 million or 10.8% of pop. age 20 or older

Epidemiology – U.S. (4)

- Morbidity/Mortality – 2007
  - 71,382 deaths (6th leading cause of death)
  - Contributed to 160,022 deaths
- Overall death risk ≅ 2x of those without DM
- Life expectancy shorted by 5 - 10 years
- Cost (2007): Total - $174 billion [$116 billion medical direct; $58 billion indirect (disability, work loss, premature mortality)]

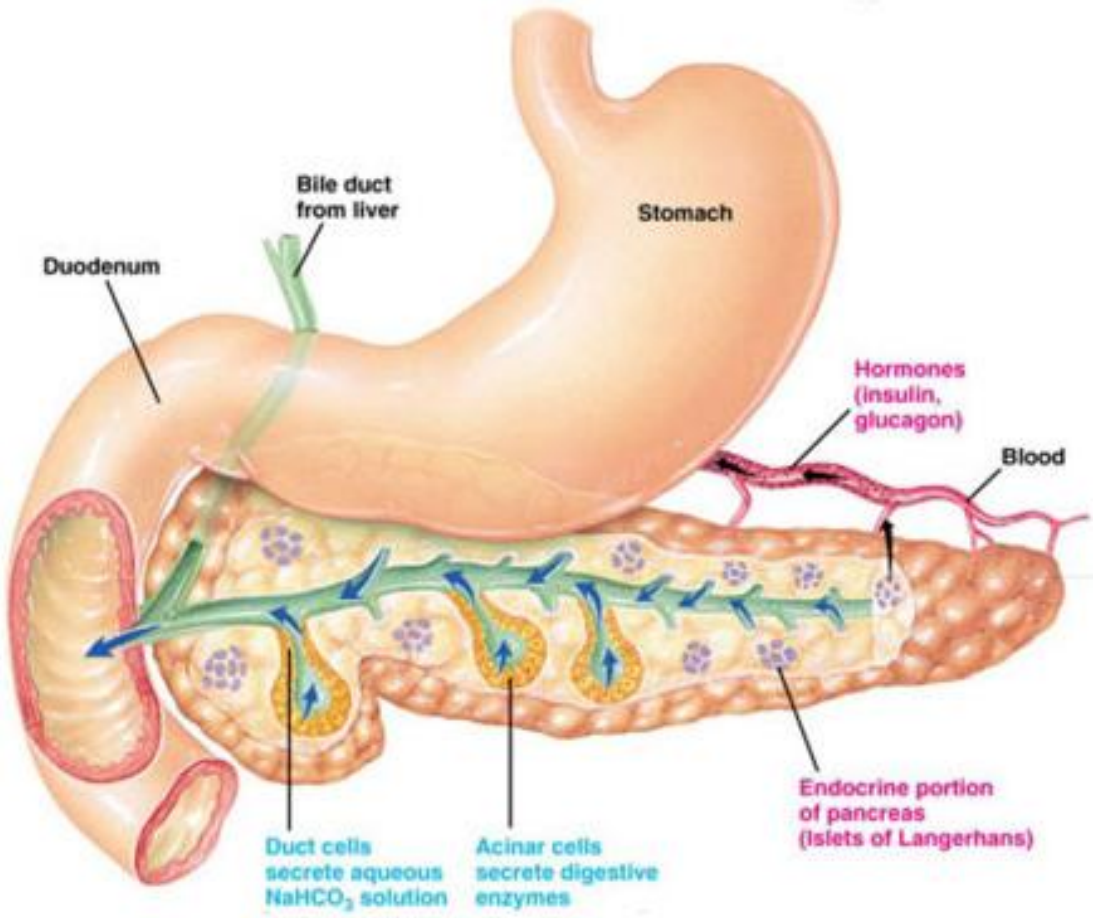
Epidemiology – U.S. (5)

- DM Complications (2005-2008) Leading cause
  - new blindness 4.2 million (28.5%) with DM 39+ had diabetic retinopathy
  - nontraumatic lower-limb amputation (> 60%)
  - kidney failure (44% of new cases in 2008 & any given year > 50,000 DM on dialysis or transplant)
  - 2 – 12X the risk for heart disease
  - 2 – 4X the risk for stroke

Epidemiology – U.S. (6)

- Developmental Disabilities & DM: No statistics were found but source after source state that the chance of diabetes prevalence, causative conditions, complications and Tx difficulty is higher in those with DD.

BLOOD SUGAR ANATOMY & PHYSIOLOGY


Bile duct
from liver
Stomach
Duodenum
Hormones
(insulin,
glucagon)
Blood
Endocrine portion
of pancreas
(islets of Langerhans)
Duct cells
secrete aqueous
$NaHCO_3$ solution
Acinar cells
secrete digestive
enzymes

Balancing [Blood Sugar]

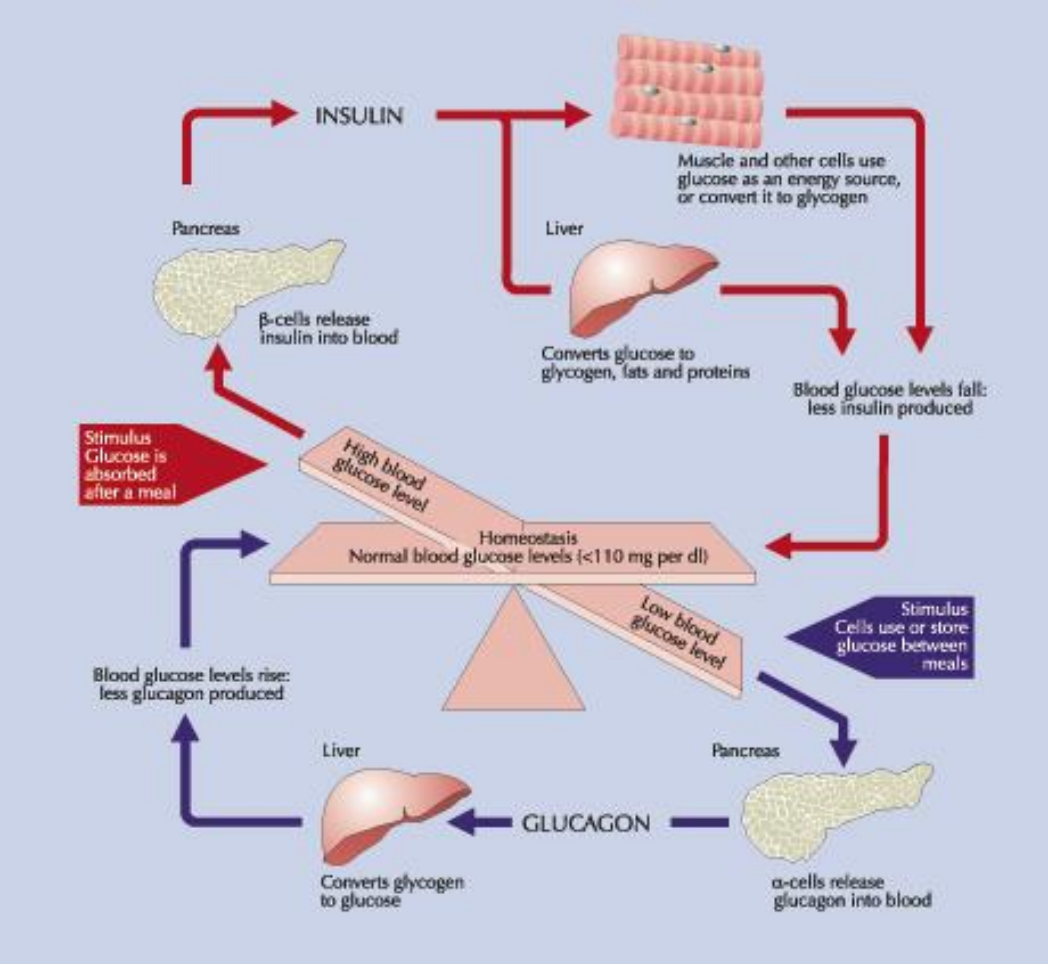
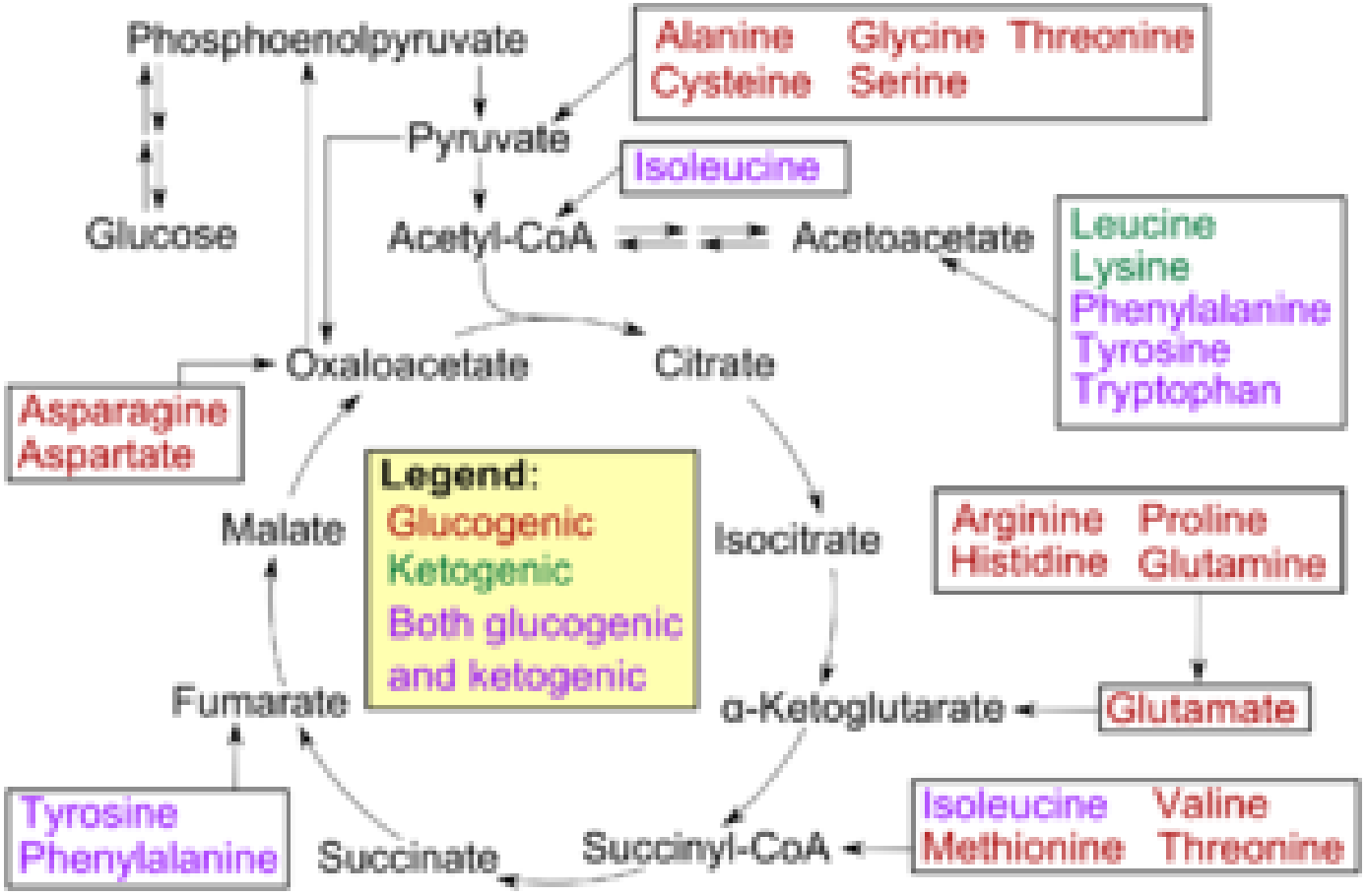


Table 1: Digestive Chemicals & Sources

Cell/Hormone	Action
α: Glucagon	↑ [blood glucose]
β: Insulin & Amylin	↓ [blood glucose]
PP: Pancreatic Polypeptide	↓ [blood glucose]
ϵ: Ghrelin	↑ [blood glucose]
Δ: Somatostatin	↓ [blood glucose]
Mucosa L cells: GLP-1	↓ [blood glucose]
Mucosa K cells: GIP	↓ [blood glucose]
Brush border: α glucosidases	↑ [blood glucose]

Kreb's/Gluconeogenesis



Facilitated Diffusion

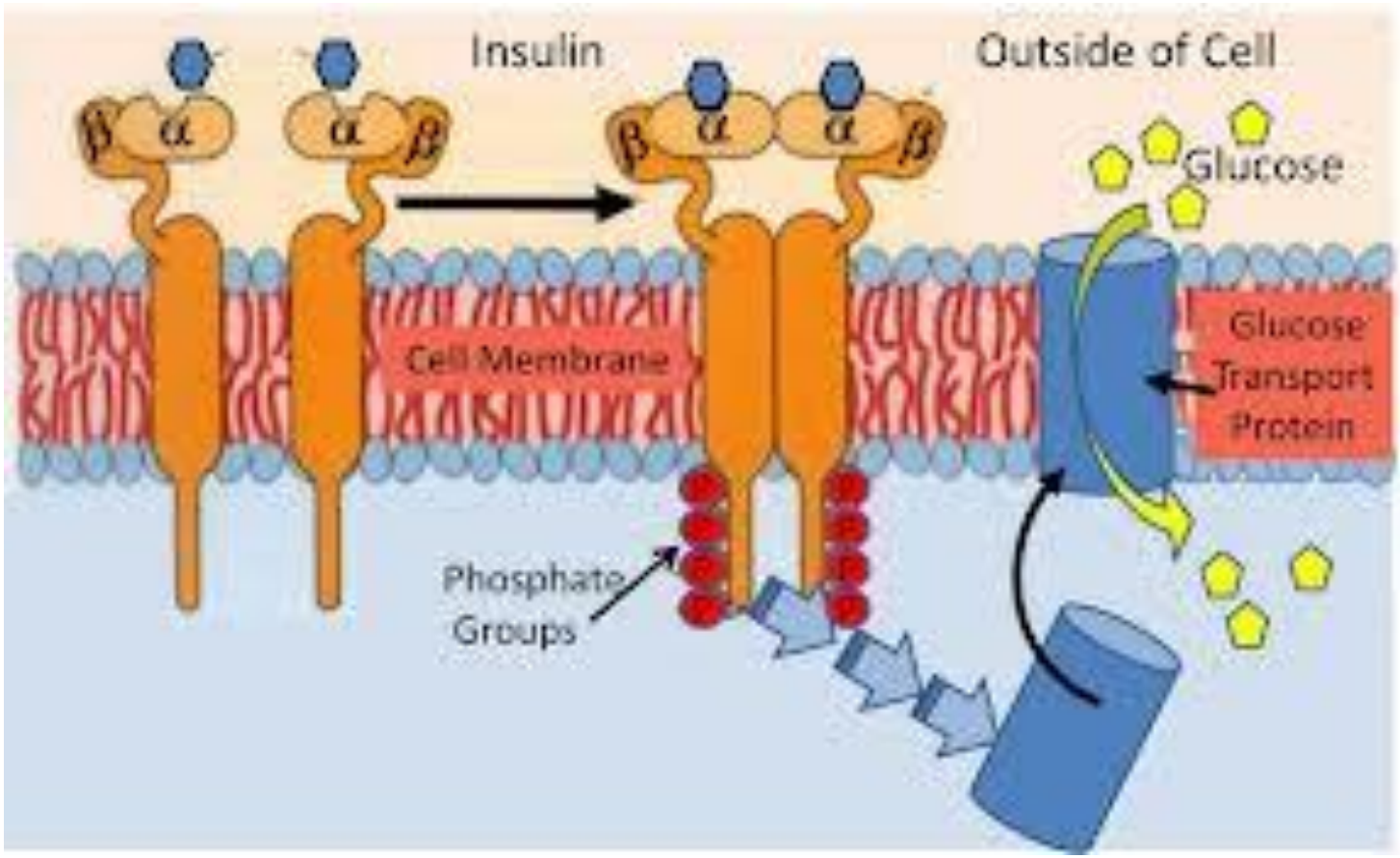


Table 2 - Insulin Functions

- ↓ [blood glucose]
  - Facilitated diffusion
  - ↑ glucogen synthesis
  - ↑ esterification fatty acids
  - ↓ lipolysis
  - ↓ proteolysis*
  - ↑ amino acid uptake
  - ↓ (inhibits) glucagon release
- Not [blood glucose] related
  - ↓ autophagy
  - ↑ K^+ uptake
  - ↓ in arterial muscle tone
  - ↑ secretion of gastric HCl
  - ↓ blood pressure
  - ↓ renal Na^+ excretion
  - ↑ K^+ excretion/↓ blood $[K^+]$

RISK FACTORS

Type 1

- Family History
- Possible genetic precursors

Type 2

- Obesity*
- Adipose tissue distribution
- Inactivity
- Family history of Type 2 DM
- Ethnicity
- Age
- Prediabetes
- Gestational diabetes
- Large baby (> 9 lbs)

ETIOLOGY/CONDITIONS

Etiology/Conditions ➔ DM (1)

- Genetic defects in β cell function
- Exocrine Pancreatic Defects
  - Chronic pancreatitis
  - Pancreatectomy
  - Pancreatic neoplasm
  - Cystic Fibrosis
  - Hemochromatosis
  - Fibrocalculous pancreatopathy

Etiology/Conditions ➔ DM (2)

- Endocrinopathies
  - Cushing Syndrome
  - Hyperthyroidism
  - Growth Hormone excess (acromegaly)
  - Pheochromocytoma

Etiology/Conditions ➔ DM (5)

- Drugs
  - Atypical antipsychotics
  - β-adrenergic agonists
  - Calcium Channel blockers
  - Corticosteroids
  - Niacin
  - Phenothiazines
  - Thiazide diuretics
  - Thyroid hormone
  - Phenytoin
  - Statins
  - Estrogen

DM PATHOLOGY

TYPE 1 – Insufficient Insulin

- β cells destroyed in antigen-antibody reaction
- DM occurs when 80 – 90% β cells destroyed

TYPE 2 – Resistance/Reduction

(1)

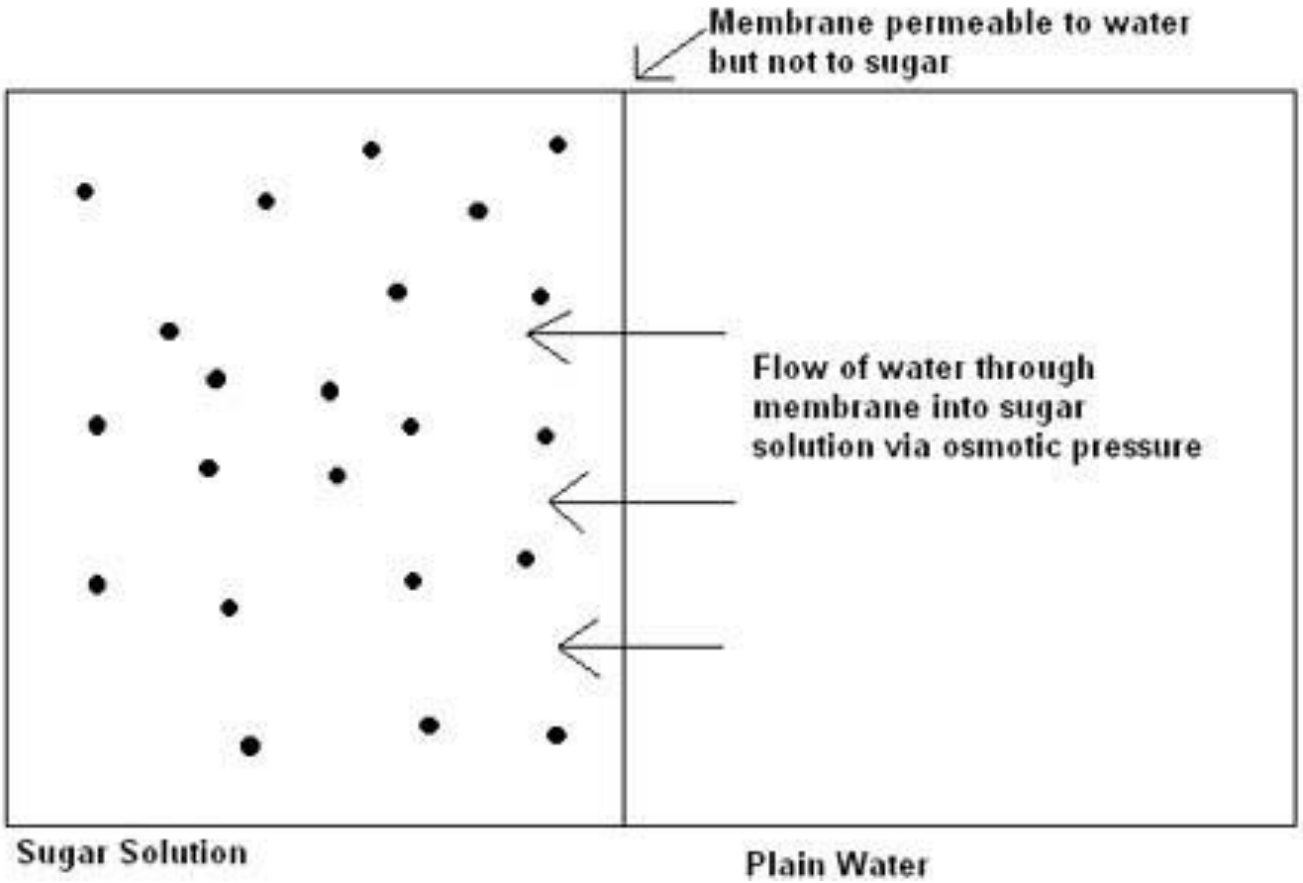
- Insulin resistance
- Contributing Factors:
  - Defective insulin or receptor & post-receptor defects ➔ inability to initiate facilitated diffusion.
  - ⬇ intracellular fat & muscle glucose from insulin lack/resistance. Initiates ⬆ liver glycogenolysis to ⬆ [blood glucose]
  - Insulin resistance ➔ ⬆ lipolysis

Types 1 & 2

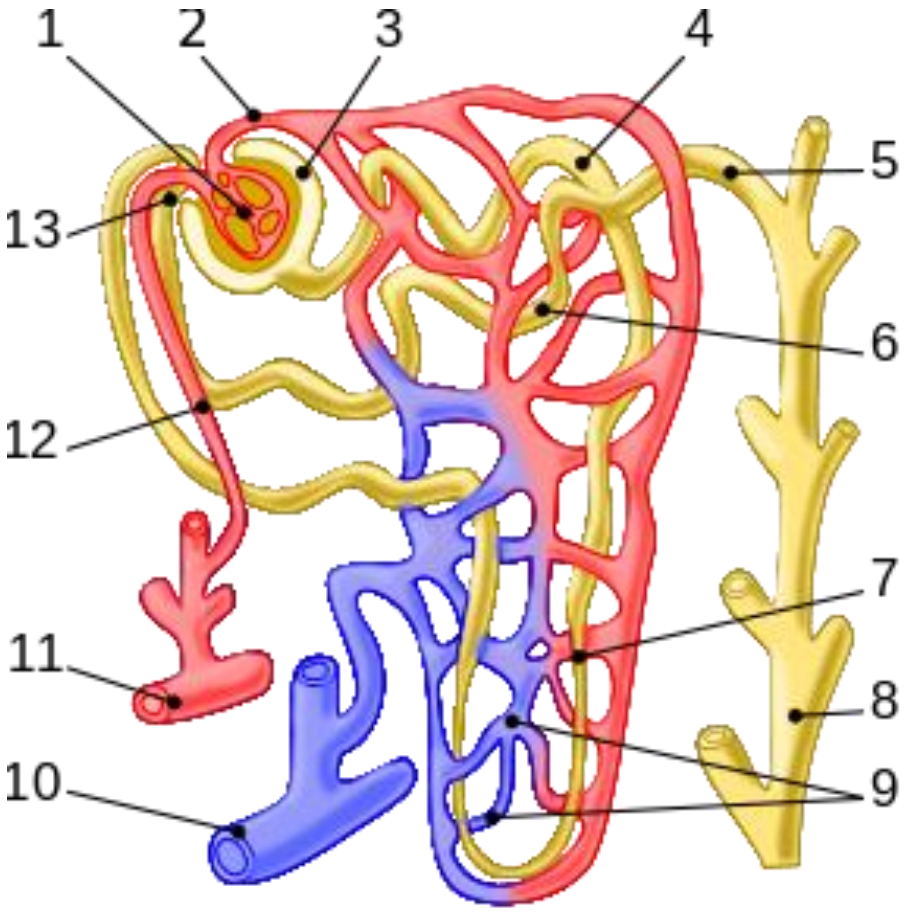
DM SYMPTOMS

Osmotic Pressure & DM

Fig.1
Osmotic Pressure



Kidney Nephron



DM Symptoms (1)

Symptom	Type		Symptom	Type	
	1	2		1	2
Hyperglycemia	✓	✓	Weight loss	✓	✓
Glycosuria	✓	✓	Fatigue	✓	✓
Polydipisia (thirst)	✓	✓	Blurred vision	✓	✓
Polyuria (frequent urination)	✓	✓	Slow healing/freq infections		✓
Polyphagia (hunger)	✓	✓	Acanthosis nigricans		✓

DM Symptoms (2)

Symptom	Type	
	1	2
Lethargy	✓	
Stupor	✓	
Ketoacidosis (DKA)	✓	unusual
Abdominal pain	✓	
Nausea/Vomiting	✓	
Hyperosmolar Hyperglycemic Nonketotic State (HHNK)		rare

Diabetic Ketoacidosis Sx

- Kussmaul breathing
  - $H_2O + CO_2 \rightleftarrows H_2CO_3 \rightleftarrows H^+ + HCO_3^-$
- Fruity (alcohol) smelling breath
- Dry skin & mouth
- Flushed face
- Nausea & vomiting
- Stomach pain

HHNK Sx

- Severe hyperglycemia
- Extreme dehydration
- Hyperosmolar plasma
- Altered consciousness, confusion or disorientation to coma without significant ketosis (seizures & death)

Hypoglycemic Symptoms

(1)

- Sweating
- Hunger
- Weakness
- Anxiety
- Dizziness/lightheaded
- Pale skin
- Shakiness
- Rapid or irregular HR
- Fatigue
- Headache
- Blurred vision
- Irritability

Hypoglycemic Symptoms

(2)

Later Symptoms (mistaken for intoxication)

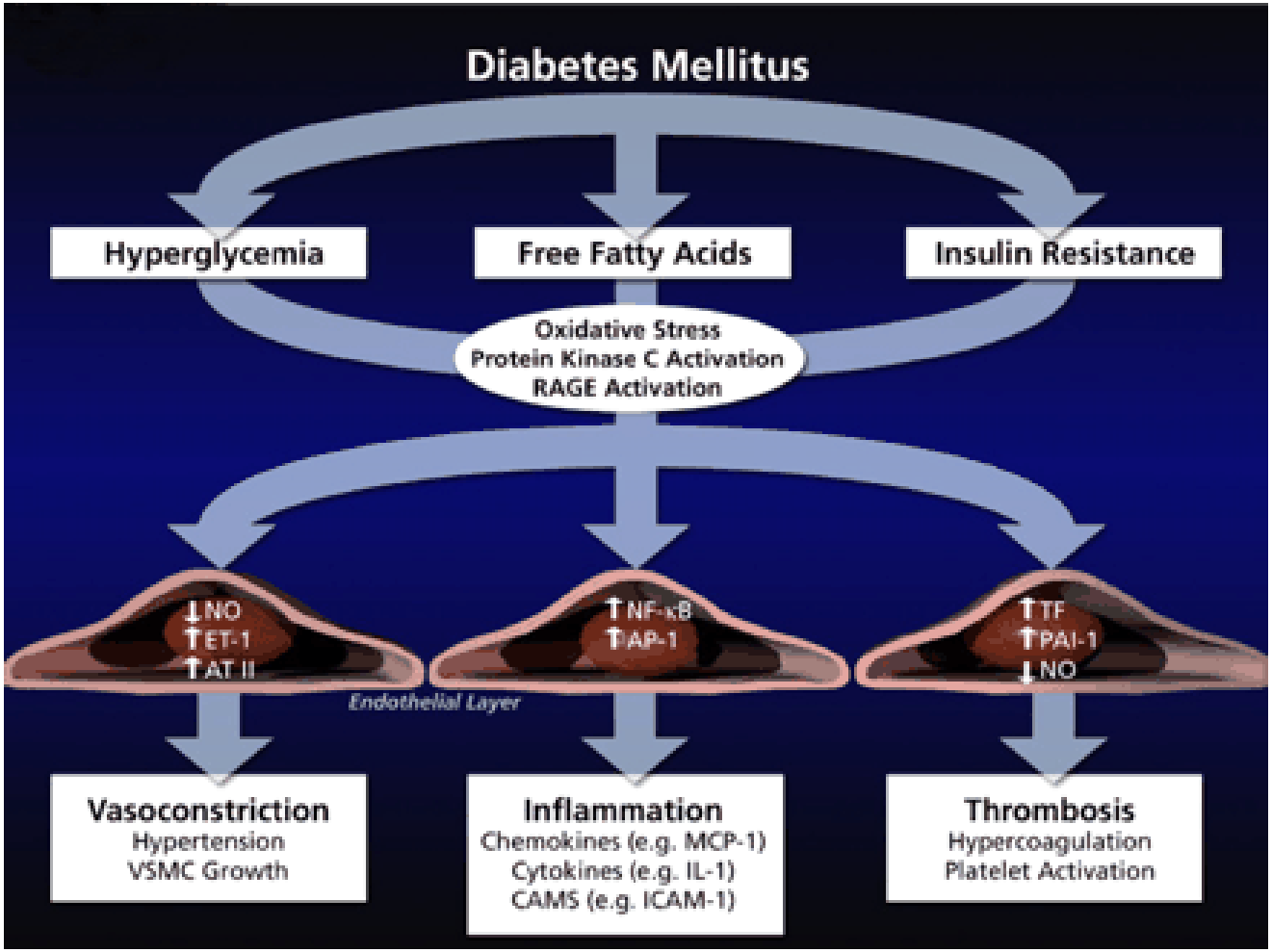
- Lethargy
- Confusion
- Behavior Change
- Poor coordination
- Convulsions

Hyerglycemic Symptoms

- Frequent urination
- Increased thirst
- Blurred vision
- Fatigue
- Nausea
- Irritability
- Hunger
- Difficulty concentrating

COMPLICATIONS

Diabetic Vascular Disease



Macroangiopathy

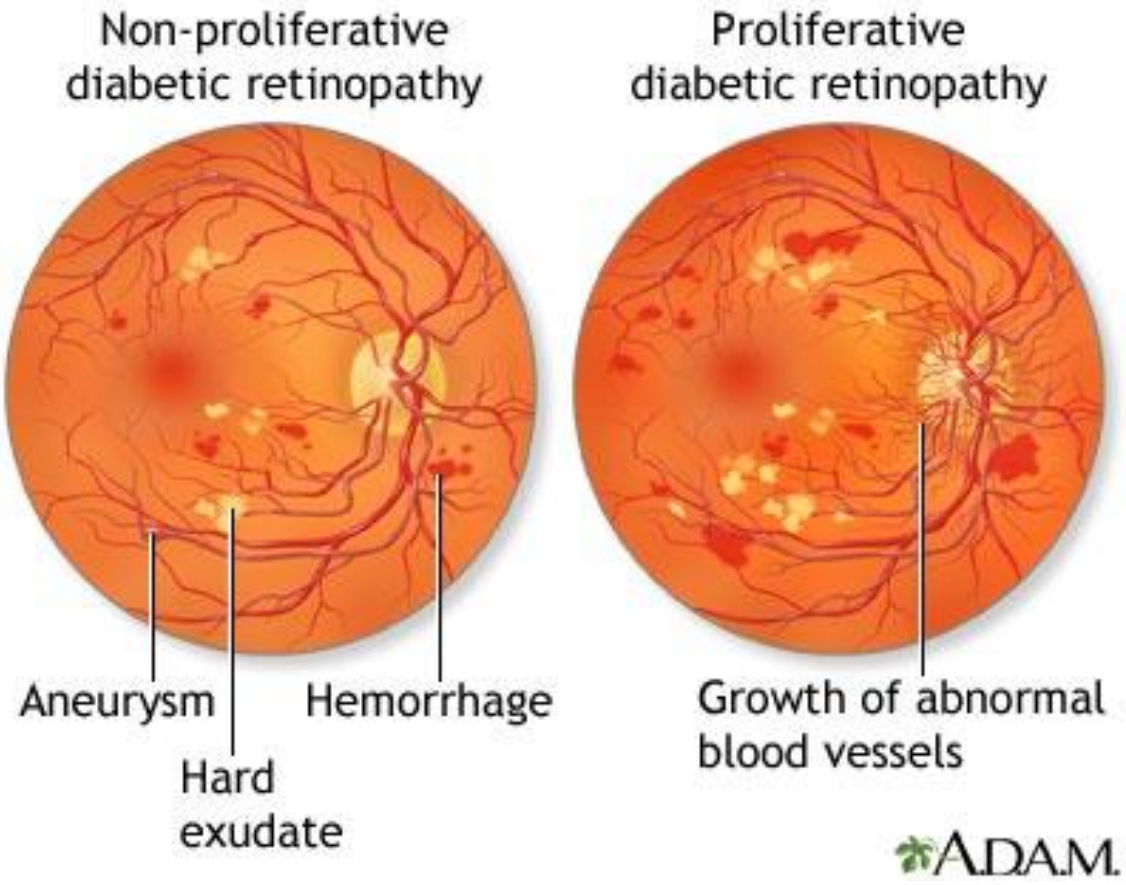
- Stroke & Cerebrovascular Disease
- Coronary artery Disease

(These are large vessel diseases ➔ decreased blood supply (ischemia) from atherosclerosis secondary to vessel endothelial dysfunction plus: procoagnlant state and antifibrinolytic state)

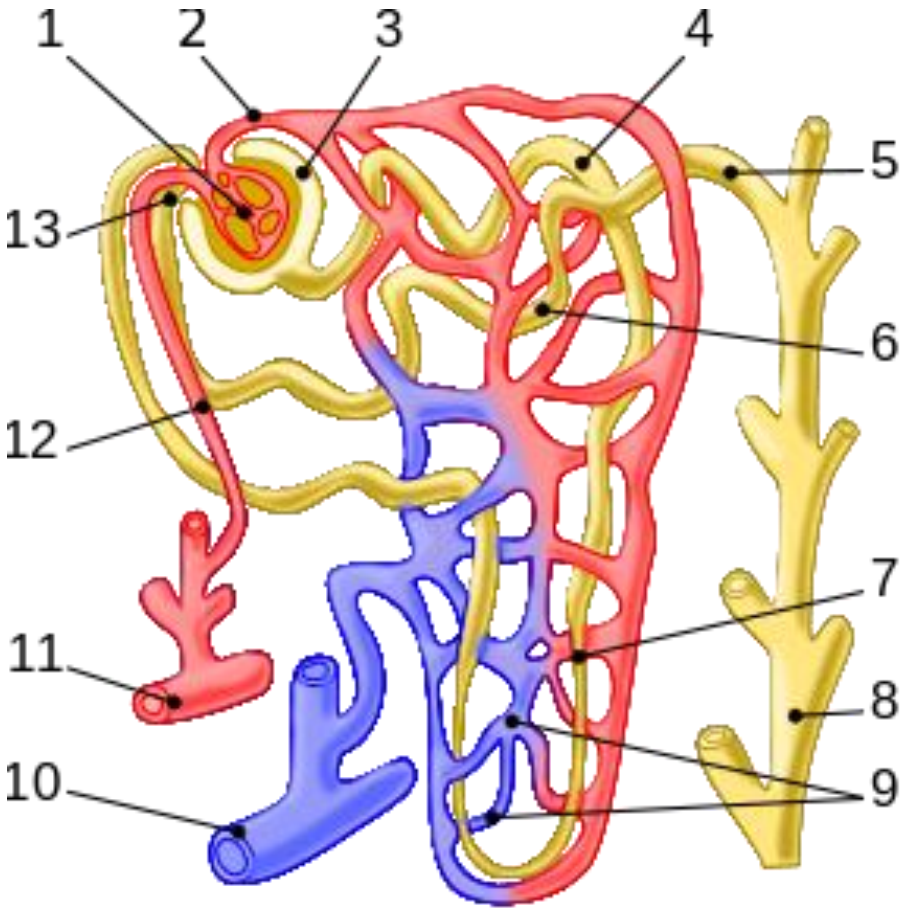
Microangiopathy

- Retinopathy
- Nephropathy

Retinopathy



DM Nephropathy

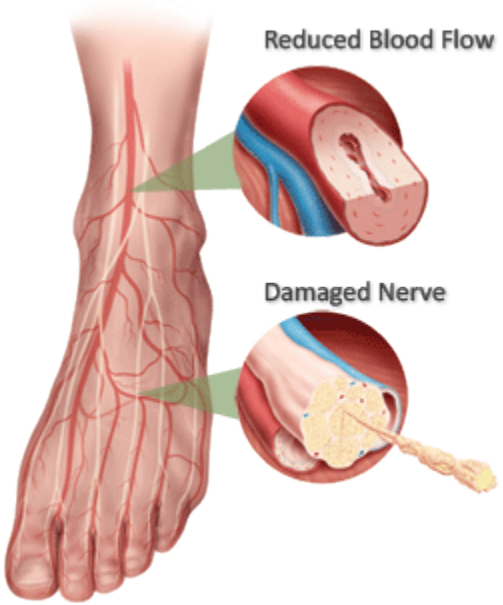


Autonomic Neuropathy

- Gastroparesis
- Diarrhea
- Impotence/Sexual dysfunction
- Orthostatic Hypotension

Peripheral Neuropathy & Microangiopathy

- ↓ Light touch, vibratory & temp sensation
- Lost foot proprioception & possible eventual ataxia, gait problems
- Ulceration
- Necrosis



Blood Pressure/Hypertension

Circulatory System (CS)	Change	B/P change
Heart stroke volume		
		
Heart Rate		
		
Artery volume		
		
Blood Volume:		
		

TREATMENT

DM Diagnosis

- History & Physical
- Diagnostic Tests – [blood sugar]
  - Random blood sugars
  - Fasting blood sugar
  - Glycohemoglobin (HbA_{1C})
  - Fructosamine Assay
  - C-Peptide Assay (Connecting Peptide Assay)

Education

All people with diabetes need to learn about their condition in order to make healthy lifestyle choices and manage their diabetes.

Eat a Healthy diet

What, when and how much you eat plays an important role in regulating how well your body manages blood sugar levels.

Exercise

Regular exercise helps your body lower blood sugars, promote weight loss, reduce stress and enhance overall fitness.

Healthy Weight

Maintaining a healthy weight is especially important in the control of Type 2 Diabetes.

Lifestyle Management

Learning to reduce stress levels in day-to-day life can help people with diabetes better manage their disease.

Take Medication if needed

Type 1 Diabetes always requires daily injections of insulin. Type 2 Diabetes is controlled through exercise and meal planning and may require medications and/or insulin to assist the body in making or using insulin more effectively.

Treatment Approach

- T1DM – Absolute insulin lack
- T2DM – Cellular resistance & relative insulin lack
- Balance insulin production/admin with insulin need
- Treatment modalities:
  - Medications – Insulin and oral antidiabetics (monitored)
  - Diet – monitored & goal directed
  - Exercise – monitored and goal directed

DM MEDICATIONS

Insulins - Rapid & Short Acting

Name	Onset	Peak	Duration
Rapid -Acting			
Humalog/Lispro	15 – 30”	30 – 90”	3 – 5 hours
Novolog/Aspart	10 – 20”	40 – 50”	3 – 5 hours
Apidra/Glulisine	20 - 30”	30 – 90”	1 – 1½ hours
Short -Acting			
Regular/Humulin	30” – 1 hour	2 – 5 hours	5 – 8 hours
Velsulin (pump)	30” – 1 hour	2 – 3 hours	2 – 3 hours

Insulins – Intermediate & Long-Acting

Name	Onset	Peak	Duration
Intermediate-Acting			
NPH (N)	1 – 2 hrs	4 – 12 hrs	18 – 24 hrs
Lente (L)	1 – 2½ hrs	3 – 10 hrs	18 – 24 hrs
Long-Acting			
Ultralente (U)	30” – 3 hrs	10 – 20 hrs	20 – 36 hrs
Lantus	1 – 1½ hrs	No peak	20 – 24 hrs
Levemir/Detemir	1 – 2 hrs	6 – 8 hrs	Up to 24 hrs

Insulins – Pre-Mixed

Name	Onset	Peak	Duration
Humulin 70/30	30”	2 – 4 hrs	14 – 24 hrs
Novolin 70/30	30”	2 – 12 hrs	Up to 24 hrs
Novolog 70/30	10 – 20”	1 – 4 hrs	Up to 24 hrs
Humulin 50/50	30”	2 – 5 hrs	18 – 24 hrs
Humalog mix 75/25	15”	30” – 2 ½ hrs	16 – 20 hrs

Self Administration

- Injection using 31 gauge, 5/16” long needle @ 90° angle for most; 45° for thin people
- Self injection, rotation of abdomen & thighs
- Tissue damage eventually leads to:
  - Hardened skin with lumps & dimpling
  - Weakened underlying fatty tissue (lipodystrophy)
  - ↓ insulin absorption → difficulty in controlling [blood glucose] levels

Oral Antidiabetic Agents - List

- α- glucosidase inhibitors – Acarbose, Miglitol
- Biguanide – Metformin HCl
- Glucagon-Like Peptide (GLP-1) agonists – Exenatide, Liraglutide
- Dipeptidyl peptidase-4 inhibitors - Linagliptin, Sitagliptin, Saxagliptin
- Human Amylin Analogue – Pramlintyde
- Meglitnide/Meglitnide derivative – Repaglinide, Nateglinide
- Sulfonylureas – Glimepiride, Glipizide, Glyburide

Oral Antidiabetic Agents - List

- Combination Medications
  - Metformin HCl & Linagliptin
  - Metformin HCl & Sitagliptin
- Weight Loss Drugs
  - Lorcaserin/Belviq®
  - Phentermine/Topiramate

Diabetes and Obesity

- Does obesity cause DM-Type 2?
- Developed eating habits early in life
- Body Mass Index
- Losing weight is simple, not easy
- Life-style change

Diabetes and Obesity (2)

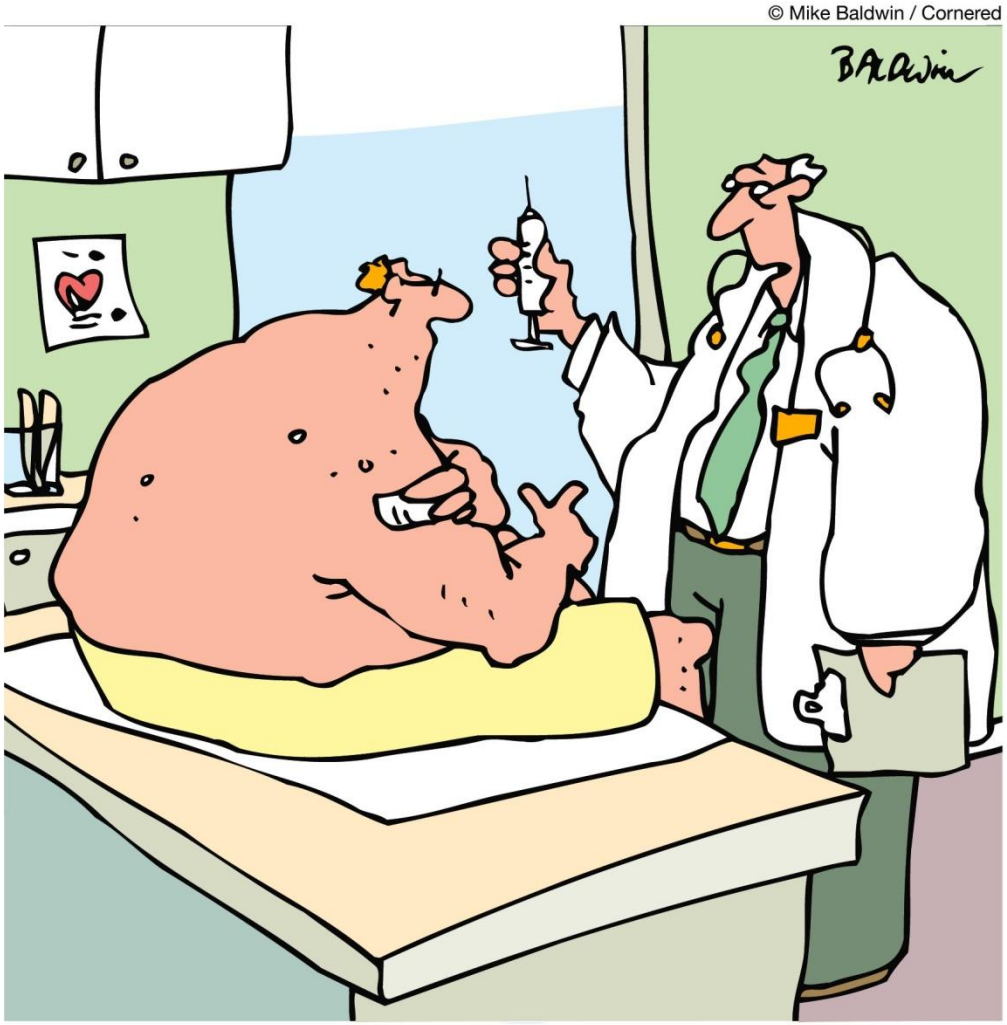
- BODY FAT % RANGES FOR MEN

RATING	AGE				
	20-29	30-39	40-49	50-59	60+
LOW	<13	<14	<16	<17	<18
NORMAL	14-20	15-21	17-23	18-24	19-25
MODERATE	21-23	22-24	24-26	25-27	26-28
HIGH	>23	>24	>26	>27	>28

Diabetes and Obesity (3)

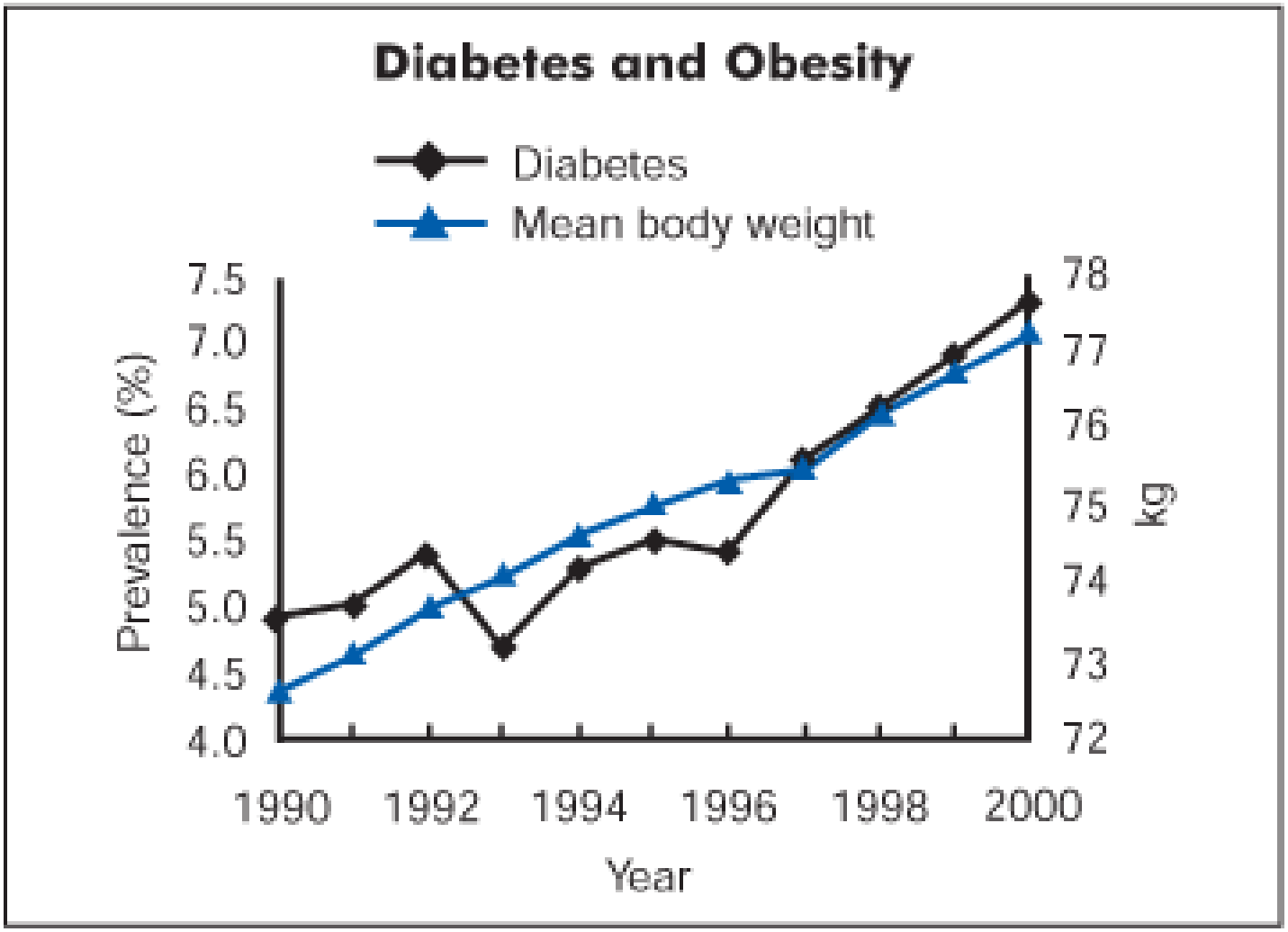
- BODY FAT % RANGES FOR WOMEN

RATING	AGE				
	20-29	30-39	40-49	50-59	60+
LOW	<19	<20	<21	<22	<23
NORMAL	20-28	21-29	22-30	23-31	24-32
MODERATE	29-31	30-32	31-33	32-33	33-35
HIGH	>31	>32	>33	>34	>35



"It wasn't really insulin. You don't have diabetes yet. It was just a warning shot."

Figure 2. Diabetes and Obesity



Diet

DIABETES &

Diet - Sources (1)

- Nutritionist/Dietitian
- Sources:
  - American Diabetics Association: www.diabetics.org
  - Academy of Nutrition and Dietetics (was American Dietetic Association) www.eatright.org

Diet – Intake Amount (2)

- Recommended caloric intake:
  - ♂, active♀ – 15 calories/lb body weight
  - Most ♀, sedentary ♂, & adults ↑ 55 - 13 cal/lb
  - Sedentary ♀, obese adults – 10 cal/lb
  - Pregnant, lactating ♀ - 15 – 17 cal/lb
  - Example: 200 lb ♂ needs to eat 2000 cal daily to maintain his weight

Diet - Tracking (3)

- Counting calories
- Exchange lists
- Glycemic Index

Diet – Exchange List

(4)

GROUP	CHO	PROTEINS	FAT	CALORIES
Starch/Bread	15/0.529	3/0.106	TRACE	80
Meat				
Very Lean		7/0.247	0-1/0.035	35
Lean		7/0.247	3/0.106	55
Med-Fat		7/0.247	5/0.176	75
High-Fat		7/0.247	8/0.282	100

Diet – Exchange List

(5)

GROUP	CHO	PROTEINS	FAT	CALORIES
Vegetable	5/0.176	2		25
Fruit	15/0.529			60
Milk				
Skim	12/0.423	8/0.282	0-3/0.106	90
Low-Fat	12/0.423	8/0.282	5/0.176	120
Whole	12/0.423	8/0.282	8/0.282	150
Fat			5/0.176	45

Diet – Exchange List

(6)

- Food exchange lists extensive
- To be determined (dietitian)
  - –Caloric intake
  - –amount of CHO, P & F
  - –Minimize Na, fats, cholesterol,
  - –Appropriate fiber amount

Diet – Glycemic Index (7)

- Glycemic Index – Measure of how quickly blood glucose level rises compared to glucose standard of 100 after eating a particular food. 95 is high GI value; 20 is low

Diet – Glycemic Index (8)

- Index tied to serving size in grams
- GI charts list foods much like exchange lists
- Problems: amt CHO actually consumed; insulin production; variability of foods; person response; impact speed/persistance

Diet - Timing (9)

- Meal timing
  - For diabetics – important
  - Especially important for those using long acting insulin
  - Intensive insulin therapy more flexible

Exercise

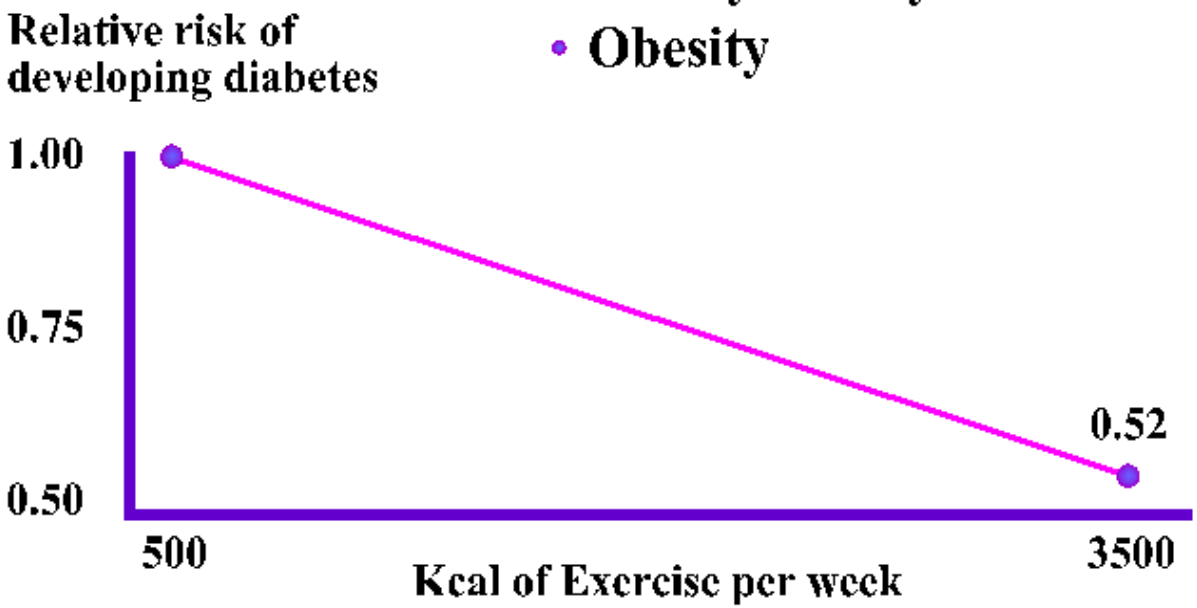
DIABETES &

"What fits your busy schedule better, exercising one hour a day or being dead 24 hours a day?"

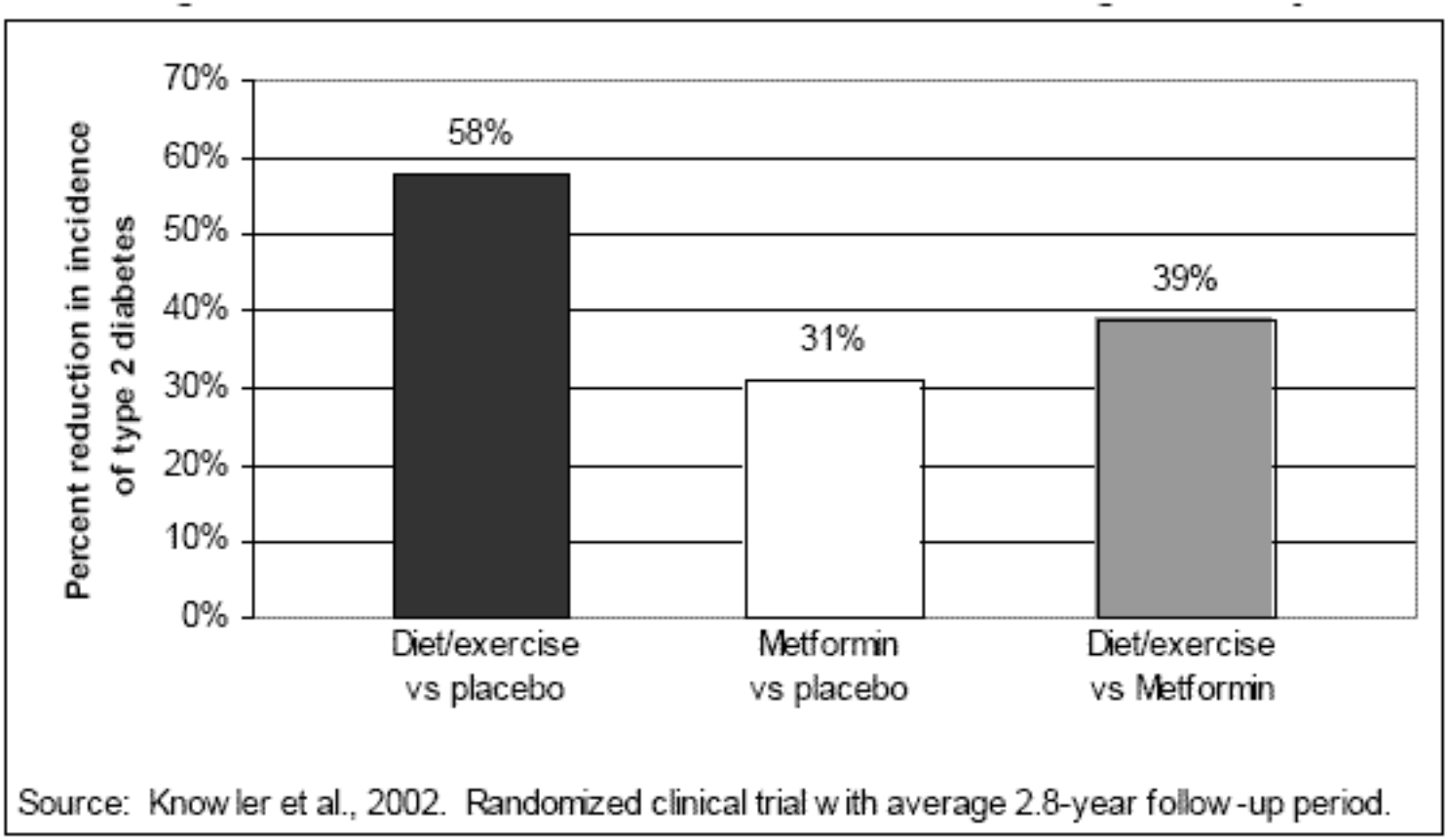
EXERCISE AND RISK OF DIABETES

Decrease risk of developing diabetes by 50% in those with high risk defined by:

- **High blood pressure**
- **Family history**
- **Obesity**



Exercise & Type 2 Diabetes



Source: Knowler et al., 2002. Randomized clinical trial with average 2.8-year follow-up period.

Exercise Benefits (1)

- Improves body insulin use
- Aerobic exercise can ↓ risk of T2DM
- Aerobic exercise can ↓ complication risk
- May delay/prevent T2DM
- Empties liver glycogen reserves
- ↓ [blood sugar] & fatty acid levels
- ↓ β cell workload/excessive production

Exercise Benefits (2)

- Weight loss and control
- Combats health conditions & diseases
- ↑energy, muscle strength, endurance partly do to ↑ body efficiency
- Improves mood
- Promotes better sleep

Exercise elements (2)

- Mode: walking, swimming, jogging, etc
- Frequency: How often exercise occurs
- Duration: How long exercise lasts
- Intensity: How “hard” exercise is
- Intensity can replace duration somewhat but be careful

Easy Exercise

- Walk while talking on phone
- Don’t use TV remote
- Wash car
- Park car at far end of shopping center lot
- Yard work
- Use stairs

Exercise Planning (1)

- SEE PHYSICIAN FIRST!
- Determine best exercise mode
- Schedule food intake, exercise & medication
- Be care of intense exercise
- With regular exercise, medications may have to be reduced. Check with physician
- Learn what exercise does to [blood sugar]

Exercise Planning (2)

- Have CHO-based food available after exercise
- May need to add CHO to meals
- With MD, adjust insulin as necessary
- Track exercise (intensity, duration, frequency)

Exercise Cautions (1)

- Wear medical alert ID (RoadID.com)
- Exercising when medication is @ peak effect
- Exercising when [blood glucose] is very high
- Watch for Symptoms of hypoglycemia (restoring of body balance can take 24 hours)
- Check [blood sugar] before, during, & after (learn how exercise effects body)

Exercise Cautions (2)

- Carry small CHO snack such as fruit or fruit drink for possible hypoglycemia during exercise
- Too much exercise (intensity/duration) can cause catecholamine production to ↑ [blood glucose]

Exercise Cautions (3)

- Don't exercise with DM-T1 & positive ketone test & [blood glucose] > 250 mg/dℓ
- If insulin injection necessary, use abdomen rather than arm or leg to absorb insulin more evenly
- Start hydrated and stay hydrated

Exercise Measures

Determining Target Range	
INTENSITY	% MAX HEART RATE
Very light	< 35
Light	35 – 54
Moderate	55 – 70
Hard	71 – 90
Very Hard	➢90
Maximal	100
220 – age. Ex: moderate [220 – age] X 0.55 to [220 – age] X 0.70	

Bariatric Surgery (1)

- Considered appropriate when BMI is:
  - 30 – 35 with significant comorbidities
  - 35 & up with serious coexisting medical conditions such as diabetes
  - 35 – 40 when no comorbidities are present

Bariatric Surgery (2)

- Bariatric Surgery not 1 specific procedure
  - Gastric band (implanted)
  - Partial gastrectomy ("sleeve" gastrectomy or biliopancreatic diversion with duodenal switch
  - Resection & re-routing of small intestine to small stomach pouch (gastric bypass)
  - Can ➔ long term significant weight loss

Bariatric Surgery (3)

- Bariatric Surgery can result in:
  - Significant long-term weight loss
  - Diabetic resolution/cure
  - Improved cardiovascular risk
  - Reduction of mortality rates from 23 to 40%
- Study showed no survival benefit among older, severely obese people

DM & Developmental Disabilities (1)

- Incidence of obesity in DD individuals 4x more common than general population
- Problems:
  - Access to healthcare for screening & treatment
  - Inability of those with DD to self manage
  - Inability to understand
  - Flawed view of disease

DM & Developmental Disabilities (2)

- Source: Prevent, Understand, and Live with Diabetes: A Guide for Individuals with Developmental Disabilities, ARC of New Jersey, 985 Livingston Ave, North Brunswick, NJ 08902
- To request copy call (732) 246-2525, ext. 35 or email info@arcnj.org
- February 2012 document

DM & Developmental Disabilities (3)

- This guide is for the individual with DM.
- It used relatively simple language and pictures
- It talks about DM prevention, warning signs, blood sugar testing, and living with diabetes.
- It is also available in Spanish