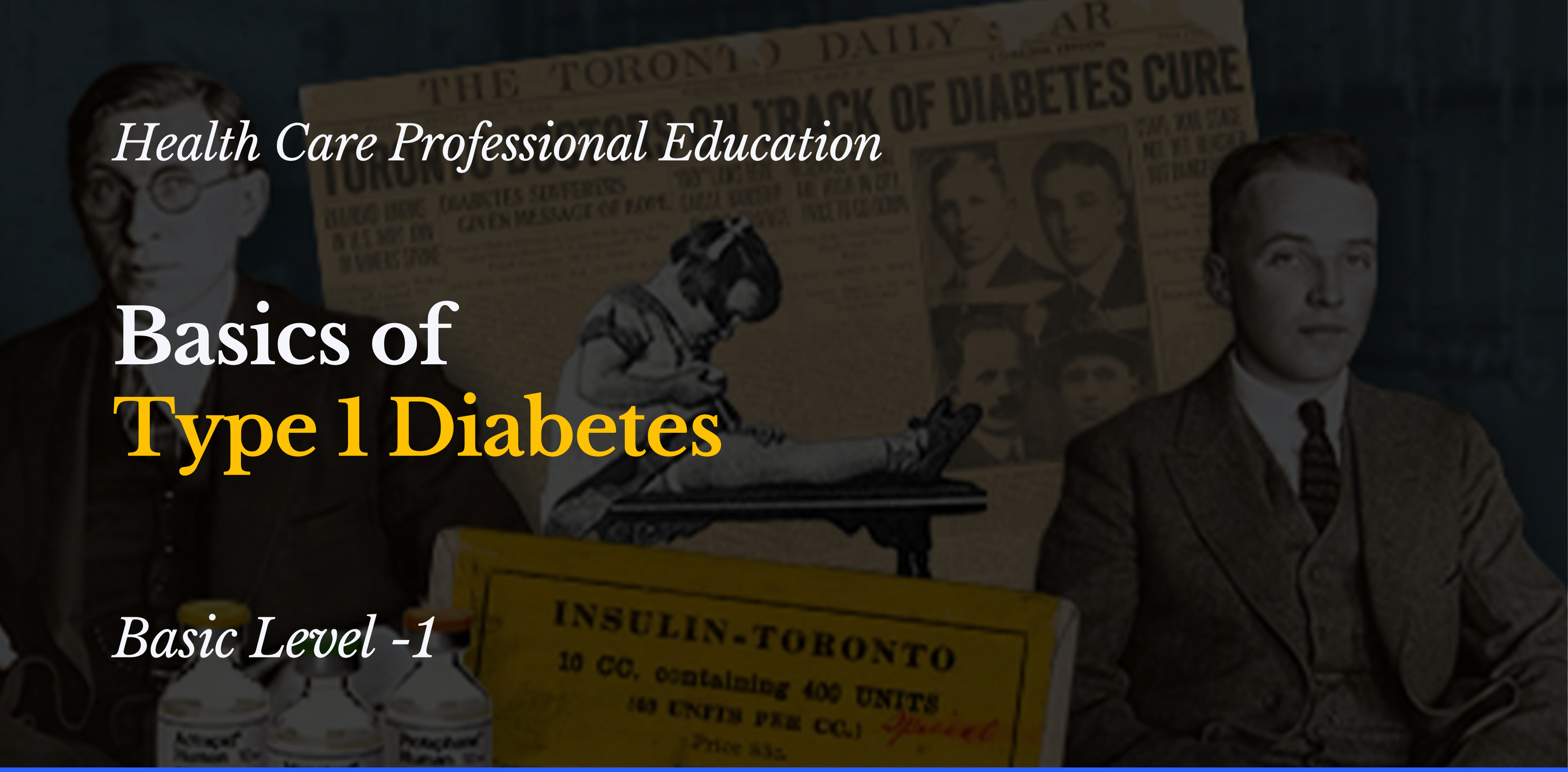


Health Care Professional Education

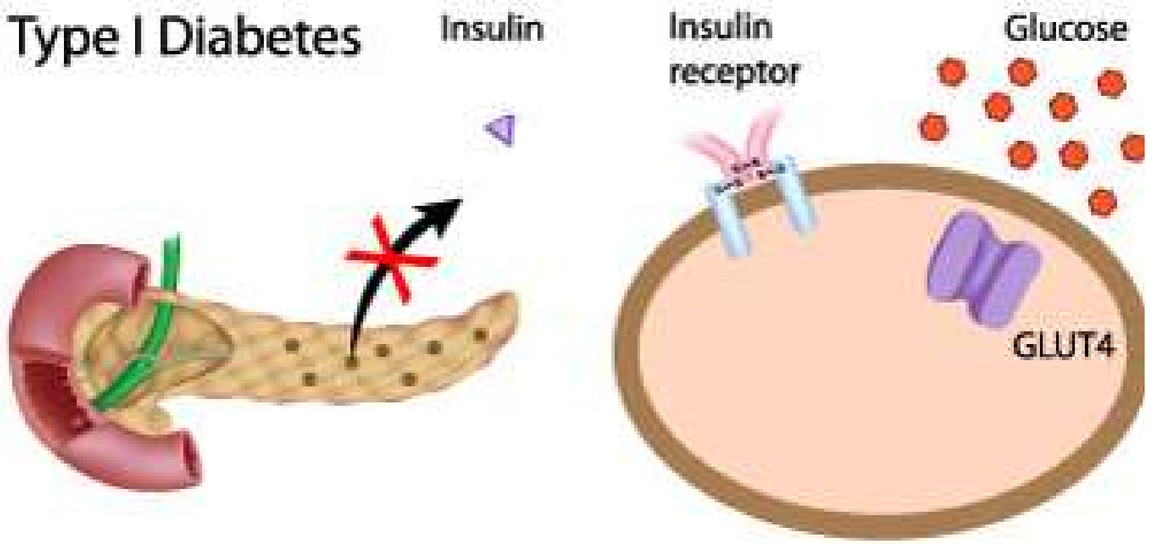
Basics of Type 1 Diabetes

Basic Level -1

INDIA

Background and Definition

- Autoimmune condition in which insulin producing beta cells are destroyed by the immune system
- The lack of insulin leads to elevated blood glucose levels, contributing to both acute and chronic complications
- Improved glycemic control can lower the risk of complications by up to 76% (DCCT Study)



Prevalence

- **8.6 Lakh** people Living with Type 1 Diabetes in India
- **10% of all PLT1D across the world live in India**
- Gregory and colleagues' study found that about **8·4 million individuals had type 1 diabetes** in 2021
- 1/5th from **low income and middle-income** countries

Ref: Guo SJ, Shao H. Growing global burden of type 1 diabetes needs multitiered precision public health interventions. Lancet Diabetes Endocrinol. 2022 Oct;10(10):688-689.

Signs and symptoms of Type 1 Diabetes

Polyuria*

Increased glucose in the blood -> increased glucose filtered by the kidneys -> **increased urination**

**may see ants attracted to urine*

Polyphagia

Without insulin, glucose stays in the blood and cells are unable to use it for energy -> **increased hunger**

Polydipsia

Increased urination and fluid loss -> **increased thirst**

Unexplained weight loss

Body breaks down muscles and fat -> **weight loss**

Excessive fatigue

Without insulin, the body is unable to use glucose for energy -> the body breaks down muscles and fat

Blurred vision

Excess glucose, AGEs, ROS and polyols can cause fluid to move in and out
-> fluid leakage from retinal blood vessel

Stomachache, nausea, vomiting

In case of severe hyperglycemia ketones are generated. It also leads to dehydration and depletion of potassium and sodium (hypokalemia and hyponatremia)

Diagnosis of Type 1 diabetes

- Raised FBG/PPBG or, HbA1c as per ADA guideline
- RBG >/= 200 mg/dl with osmotic symptoms
- Low fasting C- peptide (<0.6 ng/ml)
- Autoantibody positivity
- GAD-65 antibody primary antibody
- If negative IA-2 or, ZnT8 antibody test can be done

Glycemic monitoring

- ADA recommends self monitoring of blood glucose 6-10 times/day
- Including prior to meals/ snacks and at bed time

Month _____ Year _____

PRESCRIBED DAILY DOSE

	Regular/Rapid Acting Insulin			Glargine Insulin
	Before Breakfast	Before Lunch	Before Dinner	
Dose (in units)				
Time				

BLOOD GLUCOSE MONITORING AND INSULIN LOG

S.No	Date	Blood Glucose Monitoring								Insulin Dose Given (in units)					Remarks (Activity, illness, diet changes, blood glucose at the time of hypoglycemia & treatment given)
		Before Breakfast	2 hours after Breakfast	Before Lunch	2 hours after Lunch	Before Dinner	2 hours after Dinner	Before Bed	Between 2AM-3AM	Before Breakfast	Before Lunch	Before Dinner	Before Bed	Between 2AM-3AM	
17															
18															
19															
20															
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															
31															

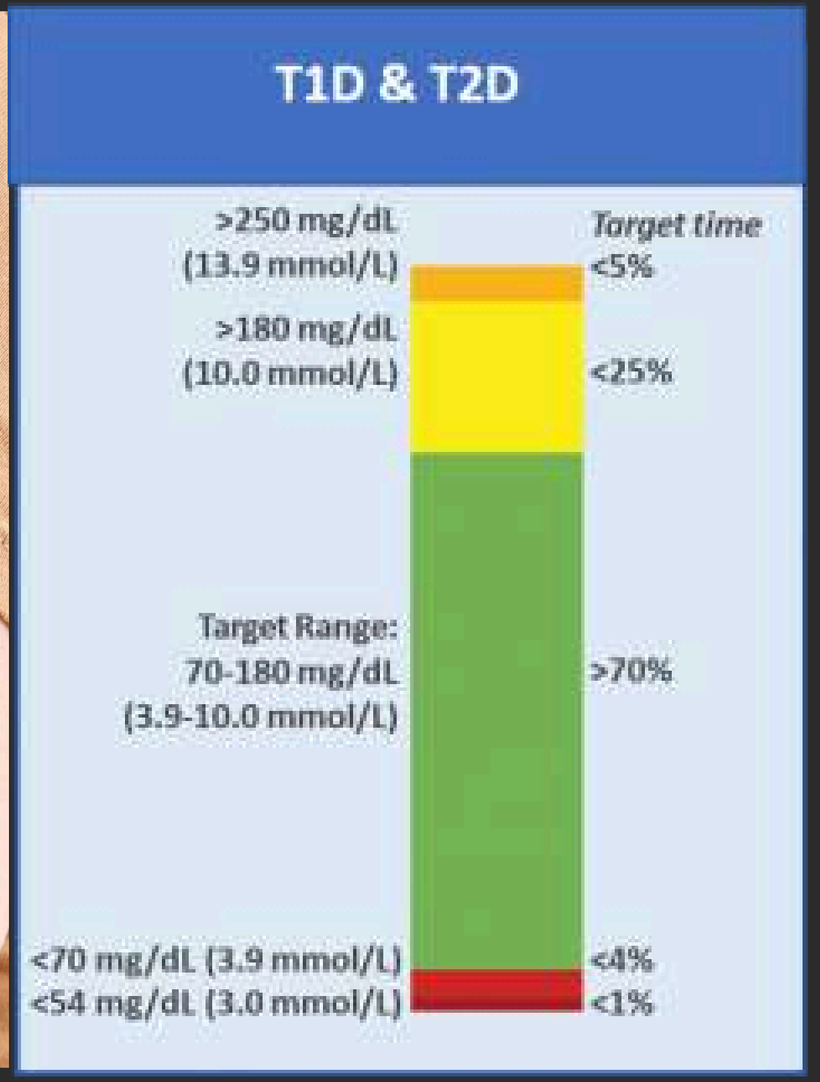
Note:

If 8-10 BG testing per day is not practical, 3-4 SMBG measurements by rotating the time of measurement can be done.

DATE	DAY	BREAKFAST		LUNCH		DINNER		BEDTIME
		Pre-feed	Post-feed	Pre-feed	Post-feed	Pre-feed	Post-feed	
	Monday	✓	✓					✓
	Tuesday			✓	✓			✓
	Wednesday	✓				✓	✓	
	Thursday	✓						✓
	Friday		✓	✓	✓			✓
	Saturday	✓				✓	✓	✓
	Sunday	✓	✓					

CGM


GLUCOMETR
My Glucose
1m ago
170
mg/dL
350
300
250
200
150
100
50
mg/dL
13:00
18:00
21:00
Add Note


T1D & T2D
>250 mg/dL
(13.9 mmol/L)
Target time
<5%
>180 mg/dL
(10.0 mmol/L)
<25%
Target Range:
70-180 mg/dL
(3.9-10.0 mmol/L)
>70%
<70 mg/dL (3.9 mmol/L)
<4%
<54 mg/dL (3.0 mmol/L)
<1%

HbA1c

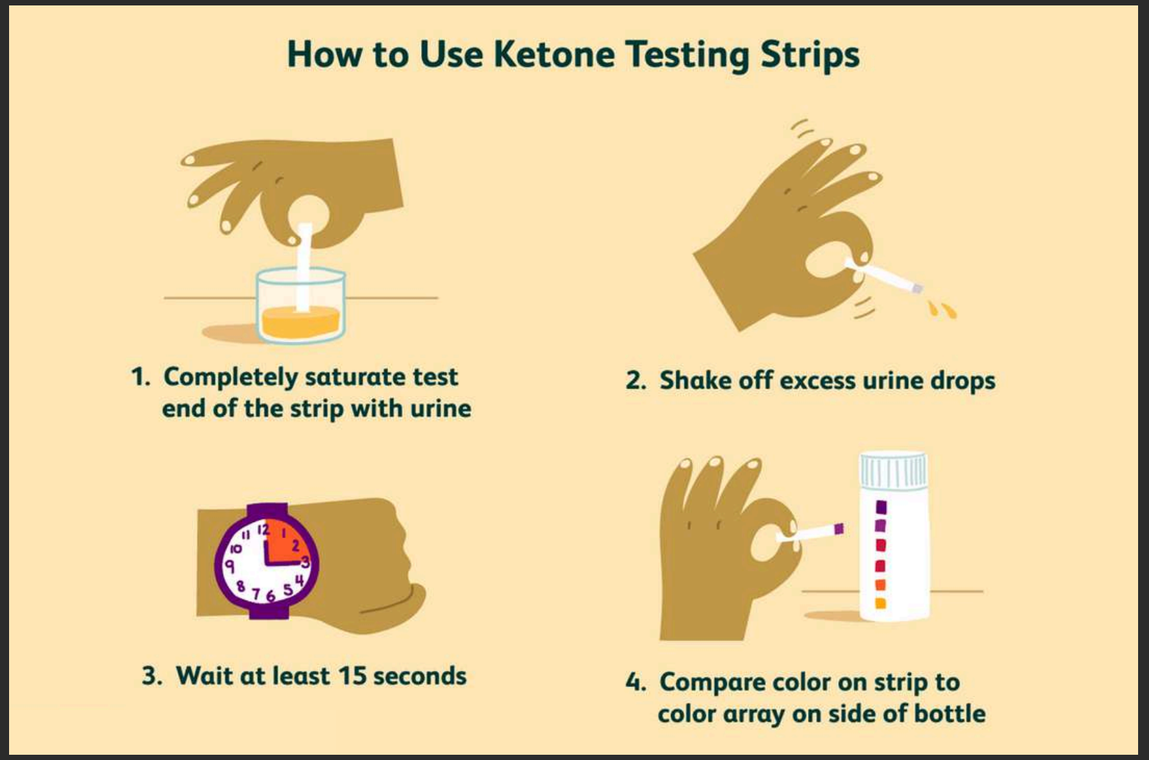
- Index of a **patient's average blood glucose level over the past 2-3 months**
- **Measurement of HbA1c (HPLC method; BioRad D10)**
- **At diagnosis and 2-3 times per year**
- Measuring **HbA1c is not a replacement for SMBG**
- **Target < 7%**
- Less stringent goal of 7.5% / 8% for those who cannot tolerate symptoms of hypoglycemia

Urine Ketones

Early detection of ketones and administration of additional insulin can prevent DKA.

When to check for ketones in urine?

- Pre-meal BG level > 240 mg/dL
- Post-meal BG level > 300 mg/dL
- Random BG level > 250 mg/dL
- Child is sick, feverish or having nausea, or vomiting or polyuria, abdominal pain, rapid breathing even if BG levels are not high



While blood ketone testing is more precise compared to urine ketones, it is more expensive and usually not available in public health facilities

Diet in Type 1 diabetes

Carbohydrates
Meals should comprise of **50-55%** carbohydrates (<40% is not recommended)

Fats
Meals should comprise of **20-25%** carbohydrates (Saturated fat should be <7%)

Protein
Meals should comprise of **15%-20%** protein

Fibre
Liberal intake of fibre such as fruits, non-starchy vegetables

Water
Should be the main drink. Avoid sugary drinks and beverages

Sucrose
<10%

Carbohydrates

Good Carbohydrates

Complex carbs

- Provide essential nutrients and release energy slowly,
- Take longer to digest
- Increase BG levels but not as fast / high as simple carbohydrates

Simple carbs

- Provide quick energy but lack the nutrients and fiber of complex carbohydrates.
- Absorbed quickly and lead to a rapid increase in BG levels
- Useful for treating hypoglycemia

Bad Carbohydrates

Refined carbs

- Processed foods with little to no nutritional value
- Quickly digested, providing minimal satiety and often contributing to weight gain, blood sugar spikes, and poor overall health.

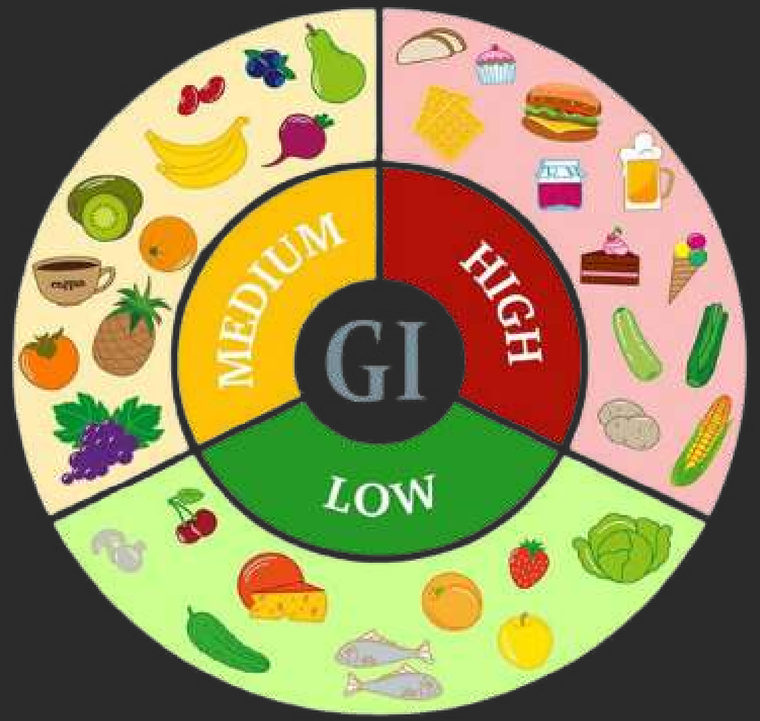
Fats

Healthy Fats	
MUFA, PUFA-6	**PUFA-3**
Olive oil *Rice bran oil* *Sunflower oil* *Groundnuts* *Soyabean oil*	*Tuna* *Salmon* *Fish oil capsules* *Walnuts* *Flax seeds*

Unhealthy Fats	
Saturated	**Trans-fats**
(Recommended < 7%)	(Recommended < 1%)
Butter & Ghee *Whole Milk* *Animal Fat* *Processed Foods*	*Ready to Eat* *Bakery Items* *Jalebi* *Fried Foods*

Glycemic index

Low GI (0-55)	◦ Beans and lentils ◦ Wholewheat breads ◦ Most fruits like apple, orange, berries, etc. ◦ Dairy products ◦ Vegetables
Medium GI (56-69)	◦ Brown rice ◦ Cereals like muesli ◦ Sweet potato ◦ Pineapple ◦ Papaya
High GI (70-100)	◦ Chips, packaged snacks and fast food ◦ Soda, and sports drinks ◦ Bakery made with refined flour ◦ White polished rice ◦ Watermelon



Glycemic load

Glycemic Load= (Glycemic Index ×Carbohydrate (g))/TDD

Low: 1-10	Medium: 11-19	High: 20+

GI = 72 Carb = 6

GL = 4

GI = 40 Carb = 15

GL = 4

GI = 62 Carb = 40

GL = 25

Insulin to carbohydrate ratio

- It is the grams of carbohydrates that can be disposed with 1 unit of insulin
- **Formula:**

$$ICR = \frac{500}{TDD}$$

- **Range:** Usually between 12-15, i.e., 1 unit insulin will dispose off 12-15 grams of carbohydrates
- ICR allows children to obtain their insulin needs at mealtimes based on the carbohydrates that will be consumed at that time

Insulin sensitivity factor

- It is the extent to which BG is expected to drop with 1 unit of insulin
- **Formula:**

Short-acting insulin	Rapid-acting insulin
$ISF = \frac{1500}{TDD}$	$ISF = \frac{1800}{TDD}$

- **Range:** Usually about 50, i.e., 1 unit of insulin will drop glucose by 48mg/dl *(to bring down the difference between actual and target blood glucose)*
- Insulin sensitivity can vary during the day/ stress/ physical activity

Carbohydrate exchange

Category	Quantity (= to 15 gm carbohydrates)
Milk Group	1 cup of milk 1 cup of buttermilk 2/3 cup of plain yogurt
Starch Group (measured after cooking)	1 slice of bread (weighing 1 ounce) 1 roti 1/2 cup rice or oatmeal 1/2 cup beans or starchy vegetable (potato, peas, sweet potato, yam) 3 cups popcorn
Fruit Group	1 small apple, orange, or pear (1/2 if large fruit) 1 small banana 3/4 cup fresh pineapple 17 grapes 1/4 cups strawberries, or watermelon 2 tablespoons raisins 1/2 cup orange juice, apple juice, or grapefruit juice

Other food components

Protein

Protein intake decreases as the child grows:

- Early infancy: 2 g/kg/day in early infancy
- Childhood (10 years): 1 g/kg/day
- Late adolescence: 0.8 – 0.9 g/kg/day

Vitamins, minerals and antioxidants

Meal planning should optimize food choices to meet recommended dietary allowance/dietary reference intake for all micronutrients

Sodium

Guidelines for sodium intake in children:

- 2.3 g salt/day

Non-nutritive sweeteners

Acceptable daily intake:

- Sucralose (0-15 mg/kg/ day)
- Saccharin (0-5 mg/kg/ day)
- Aspartame (0-50 mg/kg/ day)

Exercise Recommendations

Aerobic exercise in T1DM

Most youths with type 1 diabetes should aim for at least 60 minutes of moderate- to vigorous-intensity aerobic exercise daily

Benefits of aerobic exercise in T1DM

- Improved insulin sensitivity, blood glucose control
- Improved CV health
- Weight management

Exercise
Recommendations

Strength/Resistance training in T1DM

ADA recommendations:

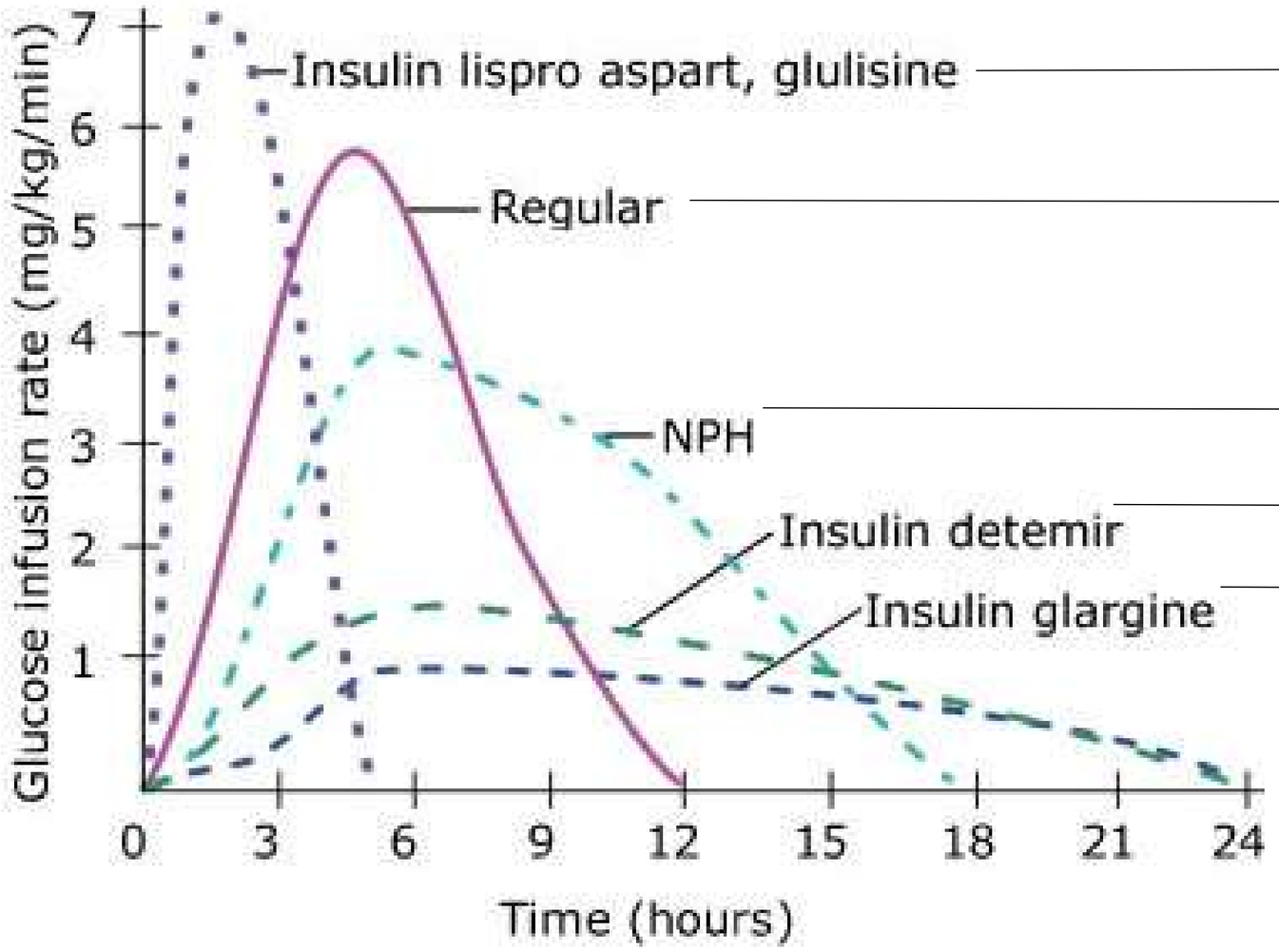
- At least two to three sessions of resistance training per week.

Resistance training can include:

- Weightlifting
- Resistance band exercises
- Bodyweight exercises

No recommendations regarding flexibility training in youths

Types of Insulin



Rapid-acting

Short-acting

Intermediate-acting

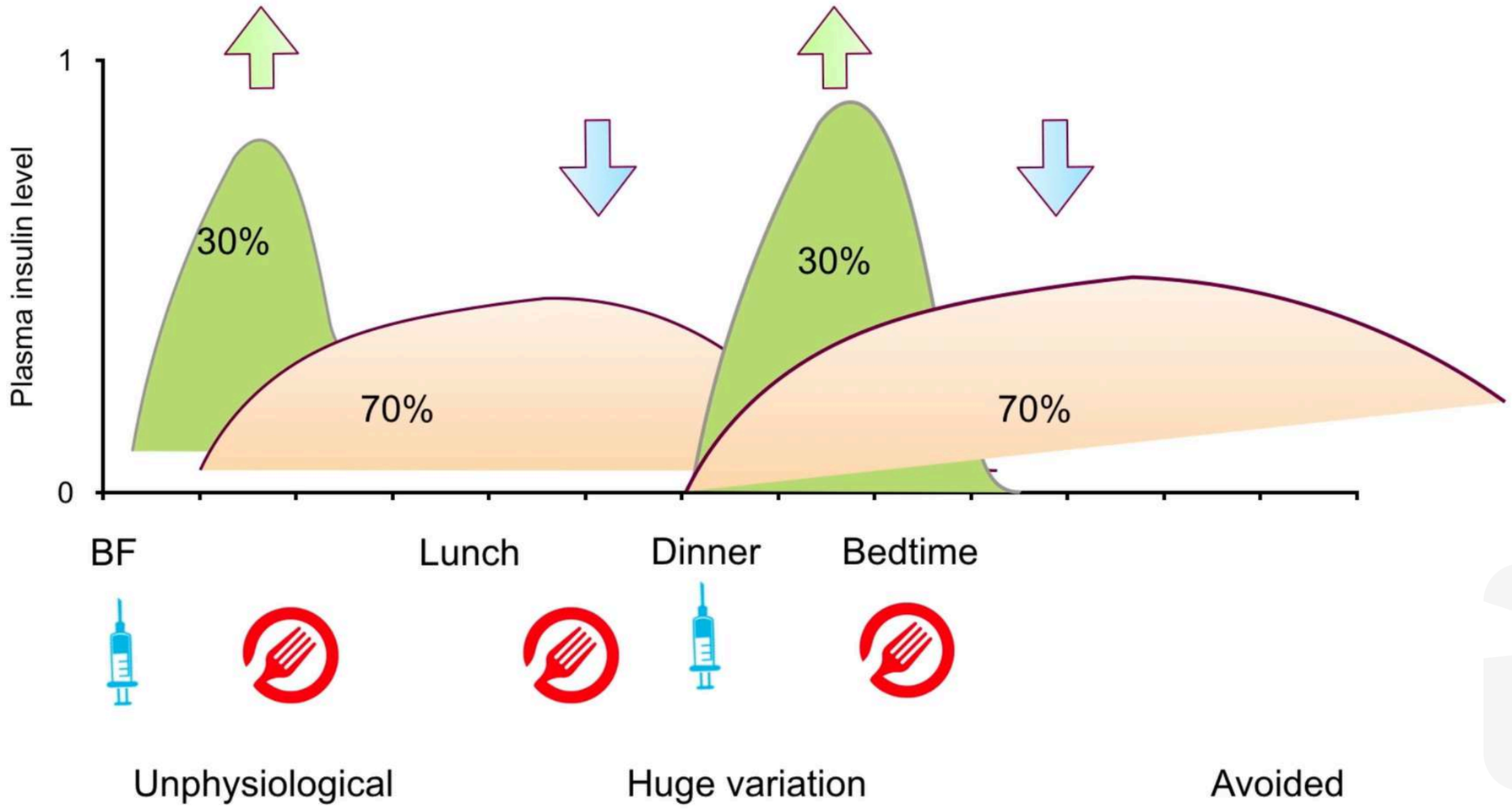
Long-acting

Long-acting

Pharmacokinetics of insulin

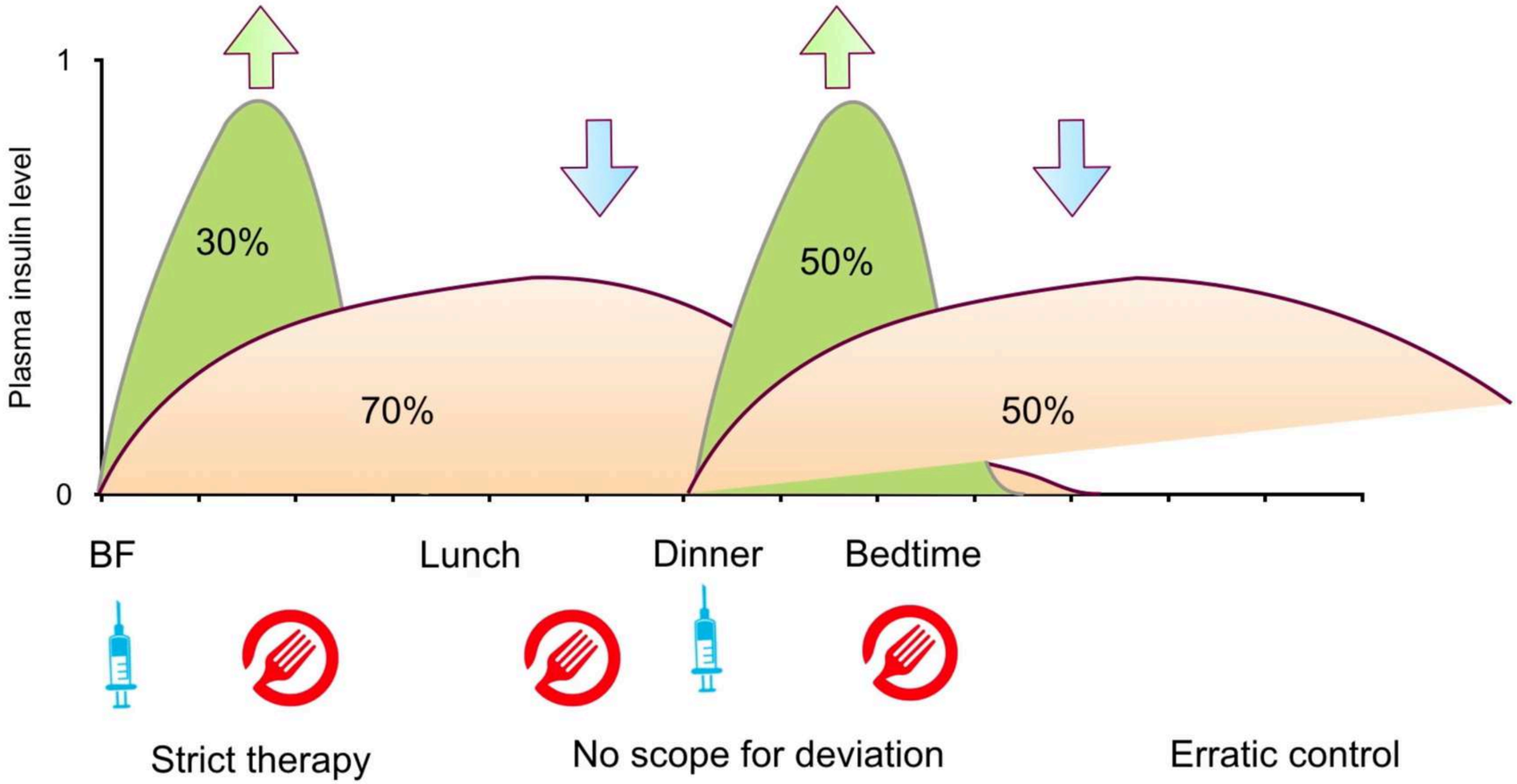
Type	Examples	Onset	Peak	Duration
Rapid-Acting	Insulin lispro, aspart, glulisine, fiasp	10-15 minutes	1-2 hours	4-5 hours
Short-Acting	Regular insulin	½ - 1 hour	2-4 hours	6-8 hours
Intermediate-Acting	NPH insulin	1-2 hours	6-10 hours	12+ hours
Long-Acting	Insulin glargine, detemir, degludec	1-2 hours	Minimal/ No peak	Up to 24 hours

Pre-mixed insulin (NPH 70 % + Regular 30 %)

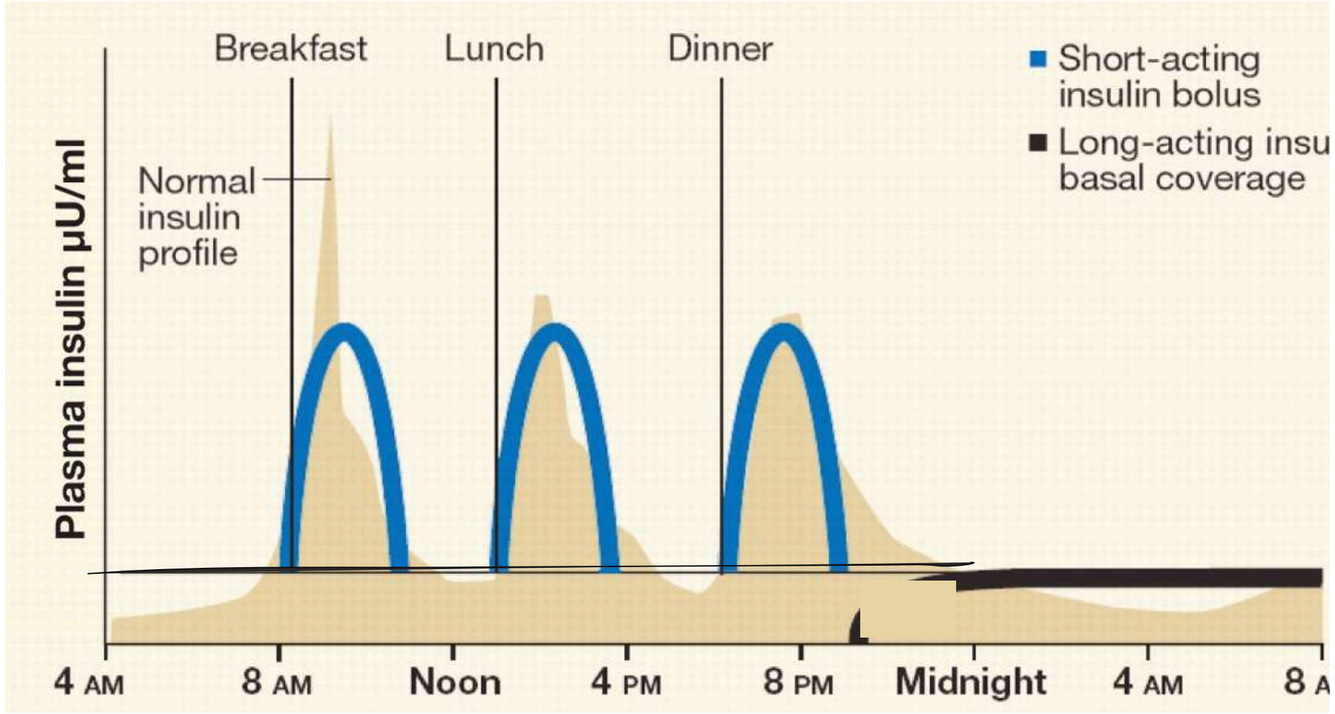


Increased risk of hypoglycemia and hyperglycemia

Split mix


1
0
Plasma insulin level
30%
70%
50%
50%
BF
Lunch
Dinner
Bedtime
Strict therapy
No scope for deviation
Erratic control

Basal-bolus insulin regimen



Basal Insulin (30-40 % 0f TDD)

- Provides a steady level of insulin throughout the day, keeping BG levels stable between meals and overnight, peak less insulin
- **One injection of long-acting insulin such as Glargine – once a day**

Bolus Insulin (60-70 % of TDD)

- Provides additional insulin needed to cover the glucose produced by the intake of carbohydrates during meals
- **3 injections of short-acting or rapid-acting insulin such as Regular insulin, before meals**

Interpretation of SMBG and adjustment of Insulin

A) Pre-Breakfast BG Levels

- Reflects the basal dose given at night
- In case of high BG levels, look at the 2-3 AM level for dose adjustments:

High pre breakfast BG + High 2-3 AM BG → Increase basal insulin that covers the night hours

High pre breakfast BG + Low 2-3 AM BG → Either decrease basal insulin OR Add a bedtime snack of low glycemic index

B) Pre-Lunch and Pre-Dinner BG Levels

- Pre-lunch levels are controlled by morning dose of regular insulin
- Pre-dinner levels are controlled by pre-lunch dose of regular insulin. Further, this value will be affected by the evening outdoor activities. The timing and amount of evening snacks (usually taken by children after returning from school) also affects this value.

High pre-lunch BG	→	Increase <u>morning dose</u> of regular insulin OR Take regular insulin with school snack
High pre-dinner BG	→	Increase <u>noon dose</u> of regular insulin OR Take regular insulin with evening snack

C) Post-meal BG Levels

- Used for adjusting the dose of the preceding pre-meal bolus insulin

High post-meal BG	→	Increase pre-meal regular insulin of preceding meal *(Eg: post-breakfast BG is high, increase the pre-breakfast bolus insulin)*

D) Bedtime BG Levels

- Important to know the effect of regular insulin given before dinner
- This value is also important in children who develop nocturnal hypoglycemia

High bedtime BG	→	Increase night dose of regular insulin by 10-15%
Low bedtime BG	→	Reduce night dose of regular insulin by 10-15%

If bedtime BG is below 80 mg/dL, extra snacking should be given to prevent hypoglycemia at night and late-night testing should be done again

Sick day rules

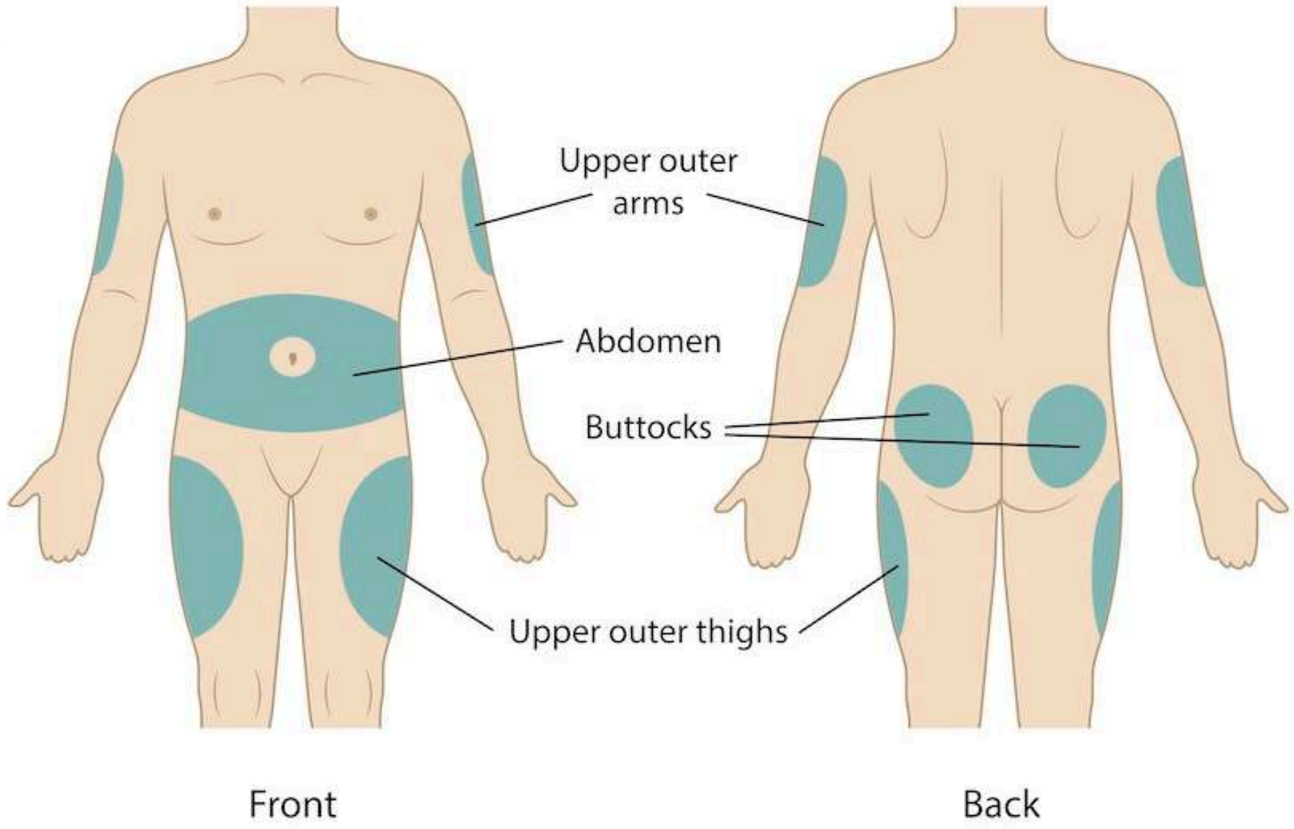
- Do not stop insulin during sick days, may need to be increased or decreased, based on the blood glucose
- Increase monitoring of blood glucose levels to 3–4 hourly
- Adequate fluid intake- Oral rehydration fluid provides a source of both fluid and energy.
- Monitor urine ketones 1-2 times per day if possible
- If blood glucose is low with ketones, (i.e. “starvation ketosis”) more sugary drink is needed before extra insulin can be given
- Elevated blood glucose results, with absence or small amount of ketones: Give: 5-10% of total daily dose of insulin (or 0.05-0.1 U/kg) as short or rapid-acting insulin repeated every 2-4 hours
- Elevated blood glucose results with moderate or large amount of ketones: Give: 10-20% of total daily dose of insulin (or 0.1 U/kg) as short or rapid-acting insulin repeated every 2-4 hours.

When to consider admission

- Very young children with diabetes, who may become dehydrated more rapidly
  - Nausea or vomiting that prevents the child from drinking
- If there are no facilities for home monitoring of glucose and ketones
  - If the acute illness is severe
  - If there is persistent ketonuria

Sites of Insulin injection

- **Upper Outer arms –** use the outer back area of the upper arm where there is fatty tissue
- **Abdomen –** except for a 2-inch circle around the navel
- **Upper outer thighs –** avoid administering too close to the bony area above the knee
- **Buttocks –** upper and outer part of the buttocks.
  The abdomen has the fastest rate of absorption, followed by the arms, thighs, and buttocks.



Step 1: Prep the insulin pen

Step 1: Remove pen cover or cap.

- Insulin should be Inspected before use, Basal Insulin like glargine is clear, colorless, with no solid particles visible, and it is of water-like consistency.

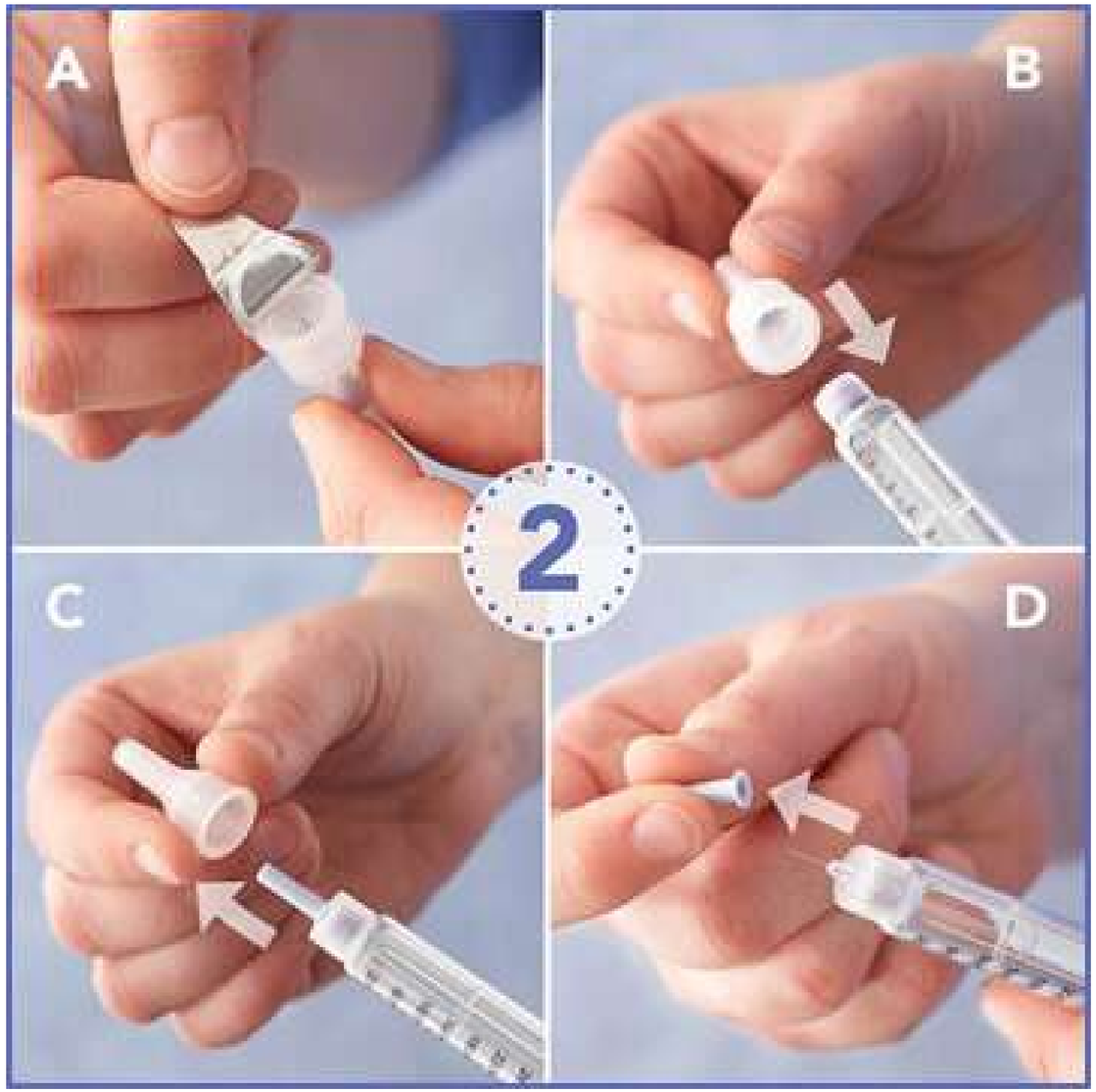
- If using milky-white (intermediate-acting) insulin, gently roll pen between palms 15 seconds to mix. Carry on with remaining steps.

Step 2: Remove paper tab and needle covers

Step 2: Get the needle ready.

1. Pull paper tab off pen needle.*
2. Screw needle onto insulin end of pen.
3. Remove outer needle cover.
4. Remove inner needle cover to expose the needle (size 4-6 mm). Throw inner needle cover in trash.

**Pen needles are available in many sizes. Ask your diabetes educator for advice.*



Step 3: Prime the insulin pen

Step 3: Get the pen ready.

1. Prime the pen and clear air from needle. Turn the dose selector knob at end of the pen to 1 or 2 units (watch dose markings change with turning of knob).
2. Press dose knob up completely while watching for insulin drop or stream to appear. Repeat, if necessary, until insulin is seen at needle tip. The dial should be back at zero after completing the priming step.

Step 4: dial in your insulin dose

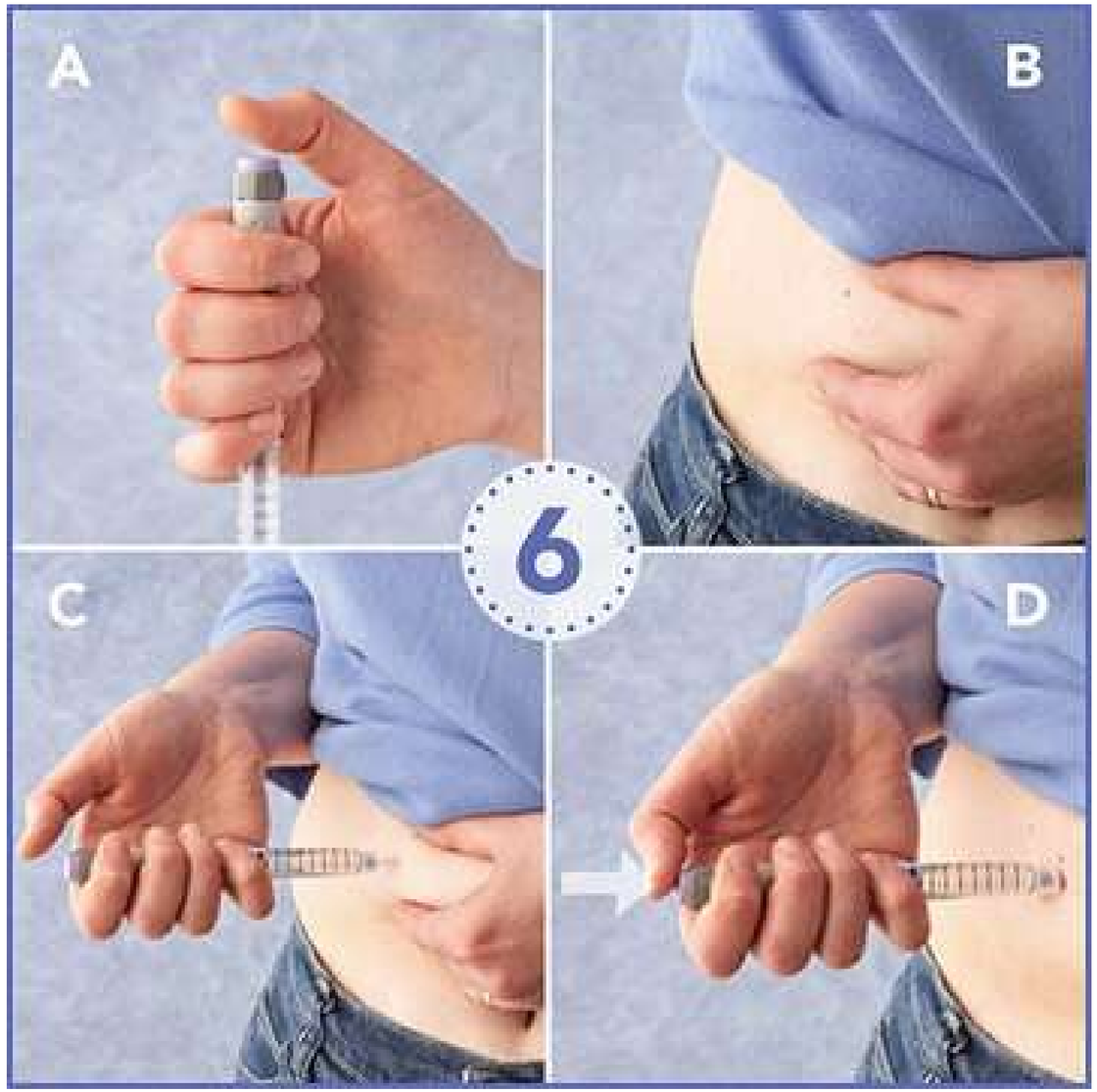
Step 4: Turn dose knob to "dial in" your insulin dose.
Double-check the dose window to assure your proper dose.

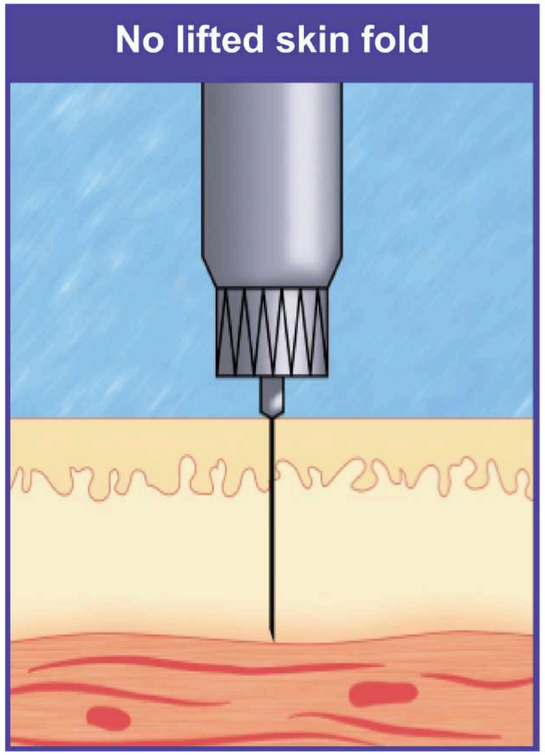
Step 5: inject the insulin

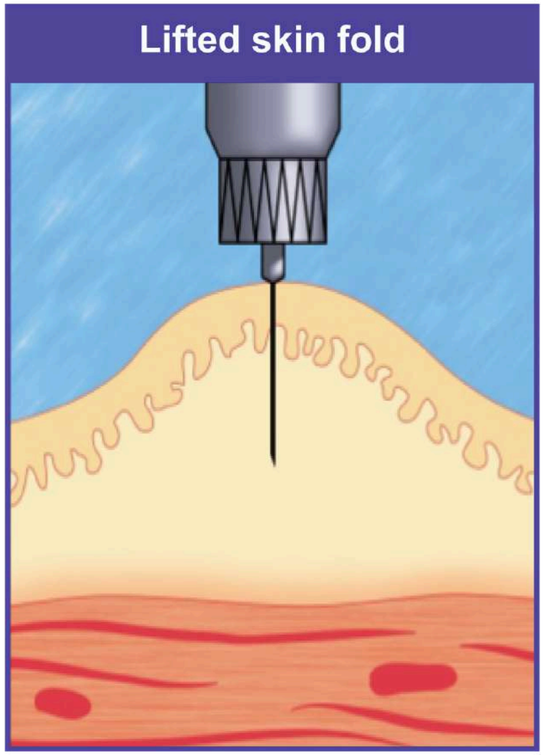
Step 5: Inject insulin.

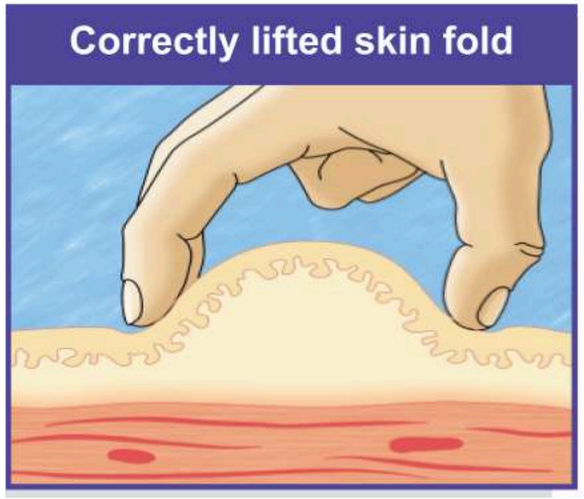
1. Curl fingers around the upper end of the pen to hold secure. Poise thumb, in air, above dose knob.
2. Gently pinch up skin with your free hand.
3. Quickly insert the needle at a 90-degree angle. Release the pinch.
4. Use your thumb to press down on the dose knob until it stops (the dose window will be back at zero). Leave the needle in place for 5-10 seconds to help prevent insulin from leaking out of the injection spot (see package insert to learn timing recommendation for your pen).

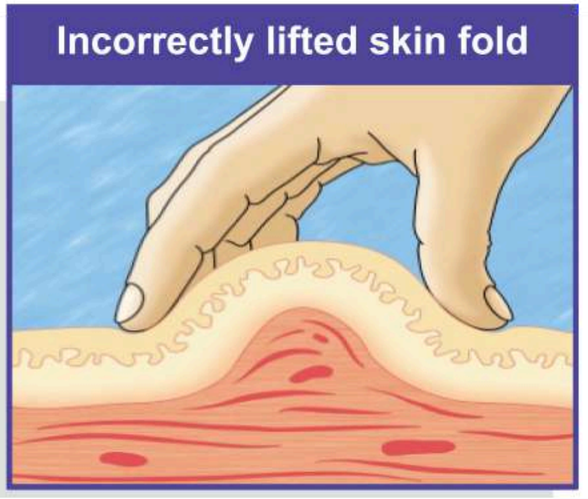
Pull the needle straight out of the skin. It is normal to sometimes see a small drop of blood or bruise. You may lightly pat the site with a tissue or cotton ball, but do not massage the area.




No lifted skin fold


Lifted skin fold


Correctly lifted skin fold

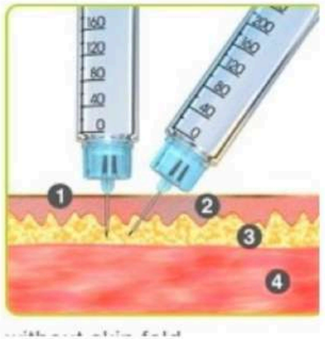

Incorrectly lifted skin fold

Step 6: Prep the insulin pen for future use

Step 6: Place outer needle cover over needle and twist to unscrew needle from pen.

Throw used needle away in hard container (an empty pill container or detergent jug are safe examples). Put the outer needle cover back on the pen.

Factors affecting insulin absorption

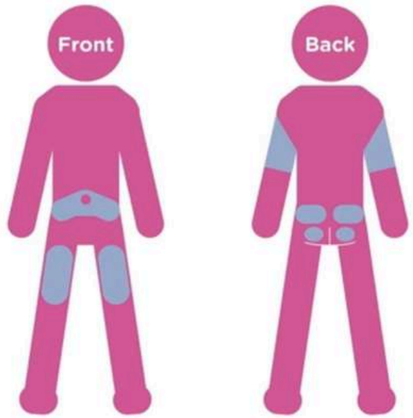


Fast with intramuscular

Faster with exercise

Faster with increased temperature

Slower with high dose



Higher with abdomen

Slower with lipohypertrophy

Insulin storage

2-8 degree

Earthen pot

Avoid freezing

No direct sunlight

Appropriate disposal

Room temperature 1 month

Refrigerator 3 month

Less than 5% effect loss

Insulin delivery devices

Reusable pen with 6 mm needle

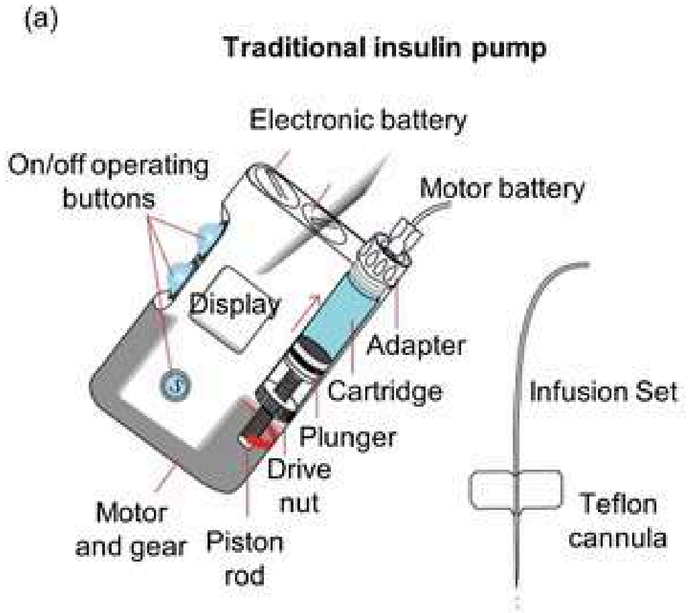
Reusable pen with 4 mm needle

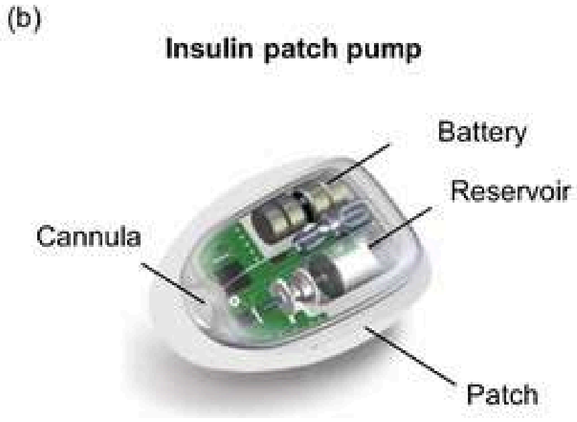
Disposable pen with cartridge

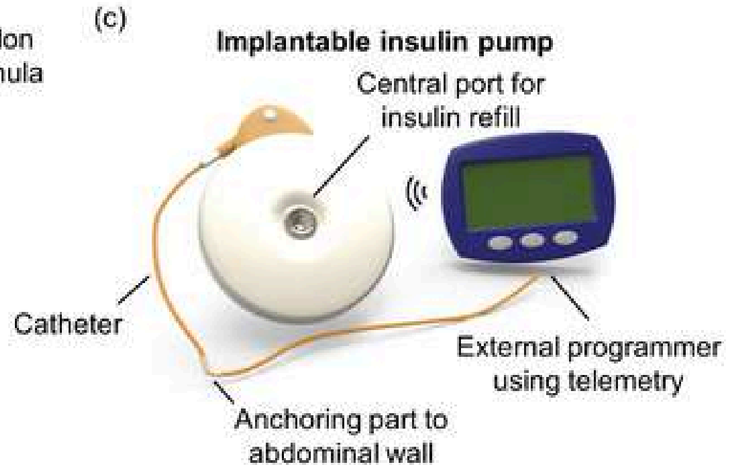
Syringe 100 IU (orange cap)

Syringe 40 IU (red cap)

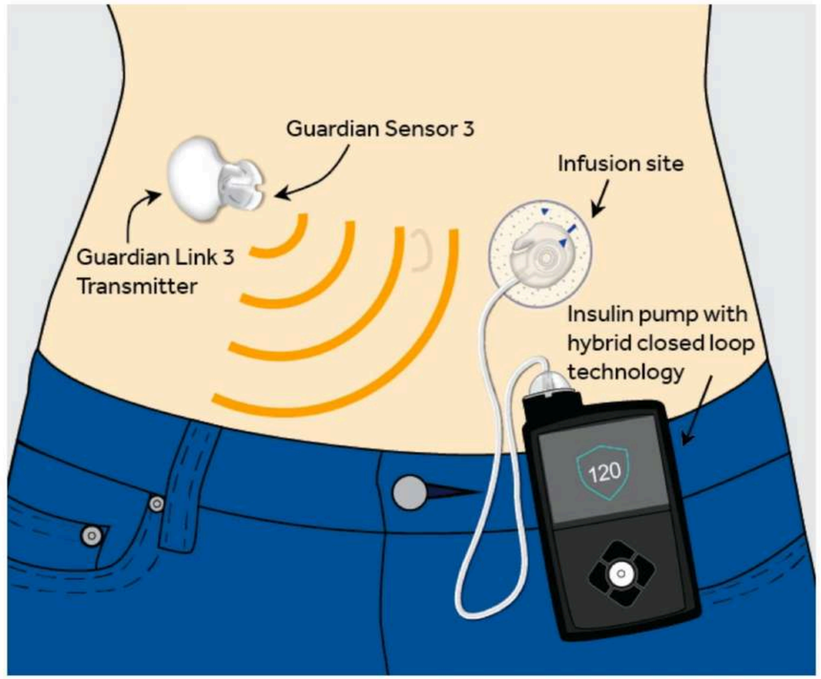
Insulin pump



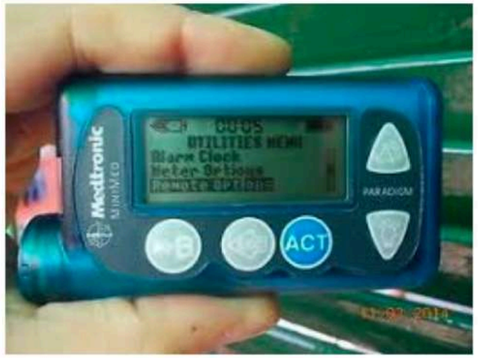




Artificial pancreas Medtronic 670G



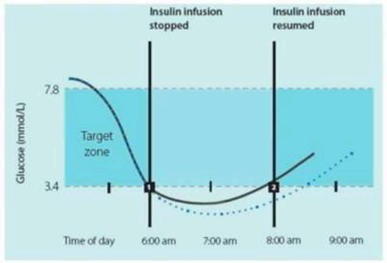
Insulin pump

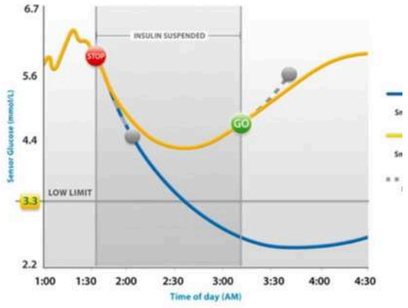


MMT 715

MMT 722 Alarm

Paradigm veo
Low glycemic suspend





Medtronic 640 G
Smart guard

Cautions during exercise

- Risk of hypoglycemia with aerobic exercise
- Risk of hyperglycemia with anaerobic exercise

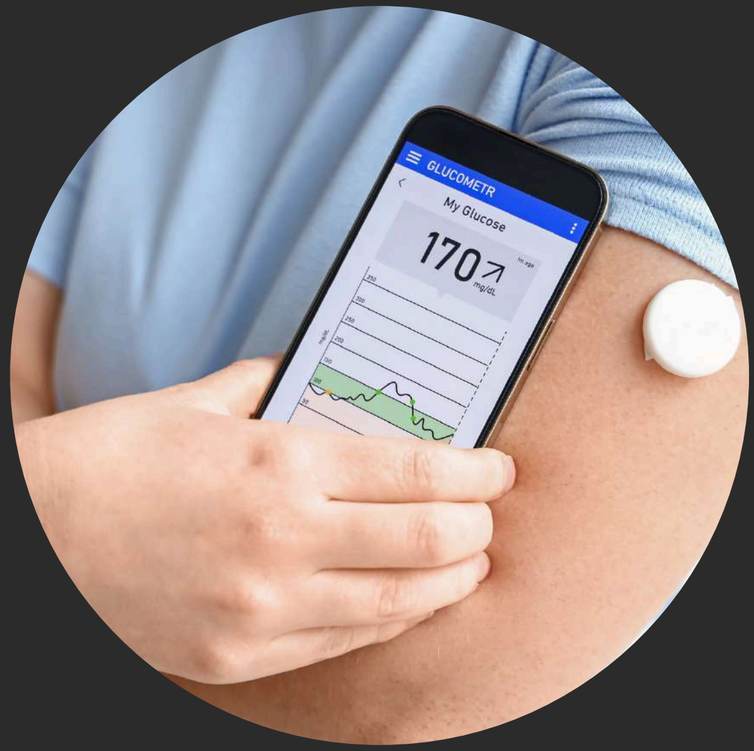
Insulin dose adjustment table for exercise. MHR, maximum heart rate. Borg scale is based on the Borg rating of perceived exertion scale [232].

	Intensity		
Duration	Low (<50 MHR % or Borg scale 10)	Medium (50–75% MHR or Borg scale 10–15)	High (>75% MHR or Borg scale >15)
<30 min	10–20%	20–45%	40–60%
30–60 min	20–30%	30–55%	50–75%
>60 min	30–50%	45–70%	100%

Blood glucose	Advice
<90 mg/dl	15-20g of glucose before starting exercise.to start exercise after blood glucose>90 mmhg.
90-124 mg/dl	Insert 10 gm of glucose before aerobic exercise,Anaerobic exercise can be started
126-180 mg/dl	Aerobic exercise can be started. Anaerobic exercise can be started blood glucose to be monitored
182-270 mg/dl	More frequent checking for blood glucose in case of anaerobic exercise
>270 mg/dl	To check for ketones and decide accordingly

Post exercise glucose balance

- Muscle insulin sensitivity remains high for long hours following exercise
- High chance of nocturnal hypoglycemia if exercise carried during later part of day
- 1gm/kg of carbohydrate and 0.3 gm/kg of protein.
- Reduction of basal dose of insulin by 20%
- For prolonged duration of physical activity basal insulin reduction to be done further up to 50%



Child with Insulin pump

- For contact sports insulin pumps may be disconnected.
- Max 2 hrs disconnection- increased chance of hyperglycemia and DKA
- 50% bolus correction to be given-to correct hyperglycemia
- Safer option 50-80% lowering the basal rate prior to exercise
- For anaerobic exercise –to prevent post exercise hyperglycemia small corrective bolus dose to be given

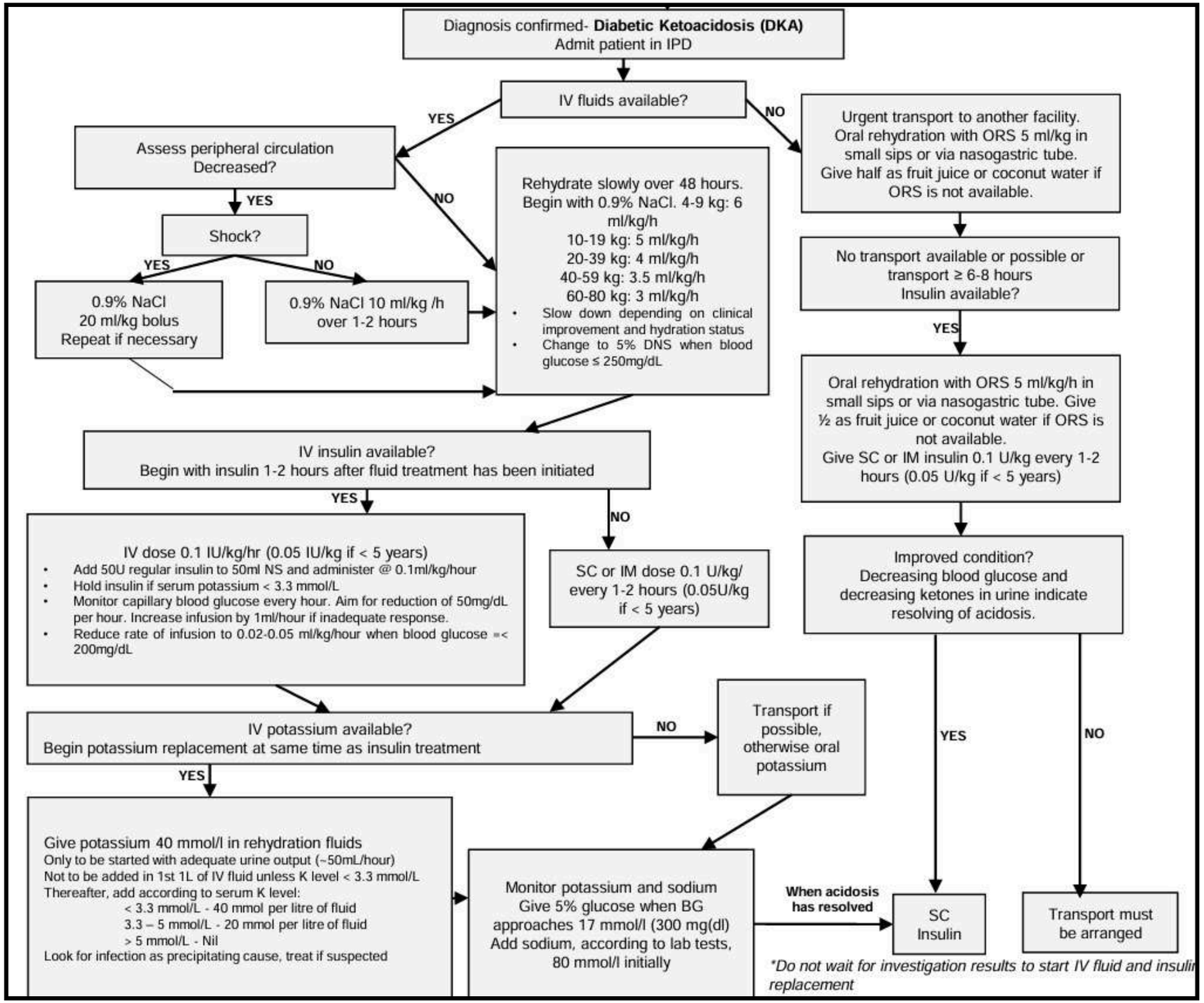
Complications

- **Acute complications** like Hypoglycemia, DKA
- **Chronic complications** like Retinopathy, Nephropathy, Neuropathy, Low peak bone mass

Hypoglycemia

- Risk factors- Insulin overdose, skipped meals, excessive physical activity
- Level 1- <70 mg/dl
- Level 2- <54 mg/dl
- Level 3- <54 mg/dl with altered mental status
- Treatment with 15 gm (3-4 tea-spoon) Carbohydrate (pure glucose preferred)
- Carbohydrate sources high in fat and protein should not be used
- Repeat CBG after 15 min, repeat carbohydrate if necessary
- For level 3 hypoglycemia, IV dextrose (2-5 ml/kg 10 % or, 1-1.5 ml/kg 25% dextrose) must be used

DKA management protocol



Lipodystrophy

- A disorder marked by abnormal distribution of body fat, affecting metabolic health.
- It Includes lipoatrophy (loss of fat) and lipohypertrophy (fat accumulation) that alters body appearance.

Lipohypertrophy Lipoatrophy

Complications screening

History and clinical evaluation for diabetes distress, depression, and eating disorders.	Begin shortly after diagnosis	Annually, or as suspected	
Height Weight BMI	At diagnosis	2 times annually 4 times annually 2 times annually	
Comprehensive nutrition education	At diagnosis	Annually	
Thyroid disorder	TSH, total or free T4	At diagnosis	Every 1-2 years, earlier if symptoms arise
Celiac disease	Anti-TTG IgA, Total IgA	At diagnosis	Within 2 years of diagnosis, thereafter every 5 years or if symptoms arise
Hypertension	Blood Pressure	At diagnosis	Every follow-up visit
Dyslipidaemia	Lipid profile	At diagnosis if person is more than 10 years of age	If abnormal (LDL > 100mg/dL), repeat annually. If normal, repeat every 2 years
Nephropathy	Albuminuria; urine albumin-to-creatinine ratio	After 3-5 years of diagnosis, beginning at the age of 10 years or at puberty (whichever is earlier)	Annually
Retinopathy	Fundoscopy		
Neuropathy	Foot examination		
Psychosocial screening (patients and family)	History and clinical evaluation for diabetes distress, depression, and eating disorders.	Begin shortly after diagnosis	Annually, or as suspected

Summary

- Early screening with FBG,PPBG or, HbA1c in children with osmotic symptoms
- C peptide and auto antibody testing if available
- Maintain a healthy diet along with 60 min of aerobic exercise daily
- Regular SMBG and adjustment of insulin dosage
- Basal-basal insulin regimen is the mainstay
- Follow sick day rules during illness
- Consider admission if presented with nausea, vomiting and persistently elevated urine ketones
- Watch out for hypoglycemia in case of insulin overdose or, skipped meals
- Annual screening for retinopathy, nephropathy, neuropathy
- Asses thyroid hormone and celiac status at diagnosis
- Appropriate psychosocial care and elimination of stigma associated with Type 1 diabetes

Thank You