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Mealtime Insulin Dosing for Type 1 Diabetes

John Pemberton
Diabetes Dietitian
Type 1 D since 2008
johnpemberton@nhs.net
(I may not reply as my kids come first, but I will if I can)

MY guiding principles & questions – number 1

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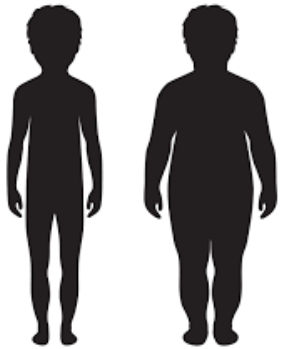
- Normal is not natural (proven over millions of years of evolution)?
  - ***Would my great grandmother recognise it as food?***
  - ***Is today's body shape is normal or natural?***



MY guiding principles & questions

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- Do I have skin in the game – Monkey see monkey do
  - ***Am I walking the talk?***

MY guiding principles & questions

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- Does my food environment betray my intentions?
  - **Are my cupboards, fridge and lunchbox filled with normal or natural food?**

Mealtime Insulin for Type 1 Diabetes

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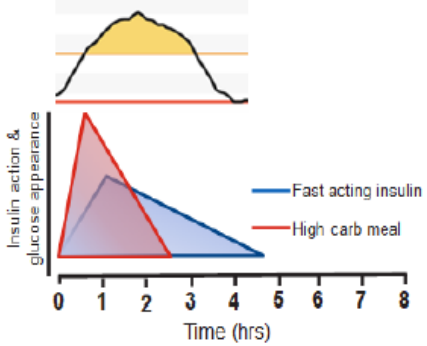
What does the Insulin to Carb Ratio (ICR) actually cover?

Glucose from digested carbohydrate and the small amount of insulin required to use fat and protein effectively.

Fast acting mealtime insulin **peaks after 60-90 minutes and lasts 4-6 hours**

High carbohydrate meals



Glucose appearance peaks at 30-60 mins, lasts 3-4 hours

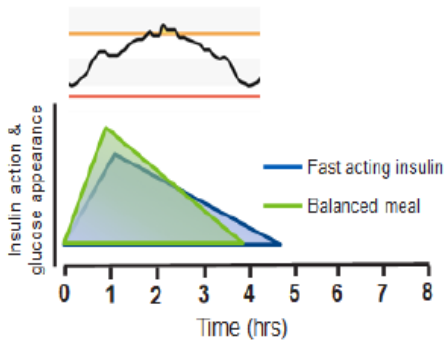
Carbs more than 55%

Breakfasts: Cereal with light milk, toast and jam, fruit bread
Meals: Jacket potato & beans, super noodles, waffles & hoops
Snacks: Cereal bars, biscuits, rice crackers, fat free yoghurt

How to better match insulin to a high carbohydrate meal?

1. Count carbs (g) within 10g accuracy & use ICR
2. Choose lower glycaemic index carb choices
3. Must be normal bolus 20 minutes before eating

Balanced meals



Glucose appearance peaks at 60-90 mins, lasts 4-5 hours

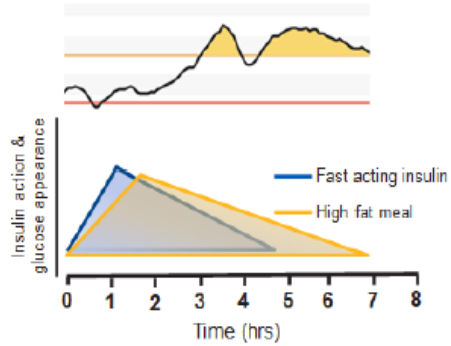
40-55% carbs, 20-40% fat & 10-20% protein

Breakfasts: Porridge with semi or full milk, egg on toast
Meals: Meat & potatoes & veg, jacket potato & cheese & salad
Snacks: Whole fruit with nuts, nut butter on toast, whole yoghurt

How to better match insulin to a balanced meal?

1. Count carbs (g) within 10g accuracy & use ICR
2. Normal bolus 20 minutes before eating

High fat meals



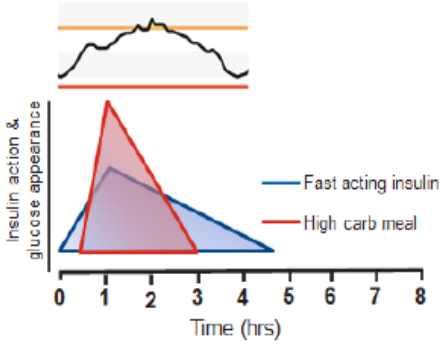
Glucose appearance peaks at 120-180 mins, lasts 6-9 hours

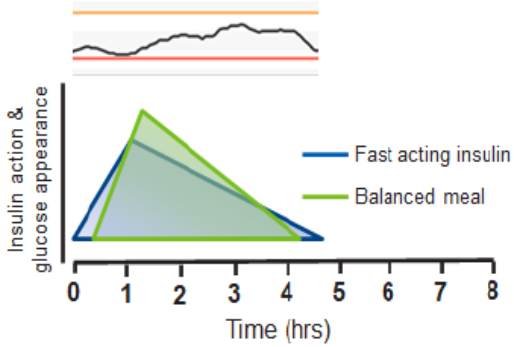
Fat more than 40g with at least 30g carbs

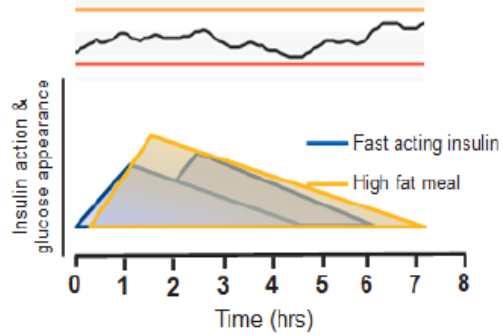
Pizza, takeaways, creamy curry, Sunday roast, English fry-up

How to better match insulin to a high fat meal?

1. Count carbs (g) within 10g accuracy & use ICR
2. Increase insulin by 25% (may need 17-124%)
3. Pump: 50% 20 minutes before, 50% over 120 mins
   MDI: 50% 20 minutes before, 50% in 60 mins
4. KISS method to adjust extra insulin and how to split







What does the Insulin to Carb Ratio (ICR) actually cover?

Glucose from digested carbohydrate and the small amount of insulin required to use fat and protein effectively.

Fast acting mealtime insulin **peaks after 60-90 minutes and lasts 4-6 hours**

What does fast acting insulin do?

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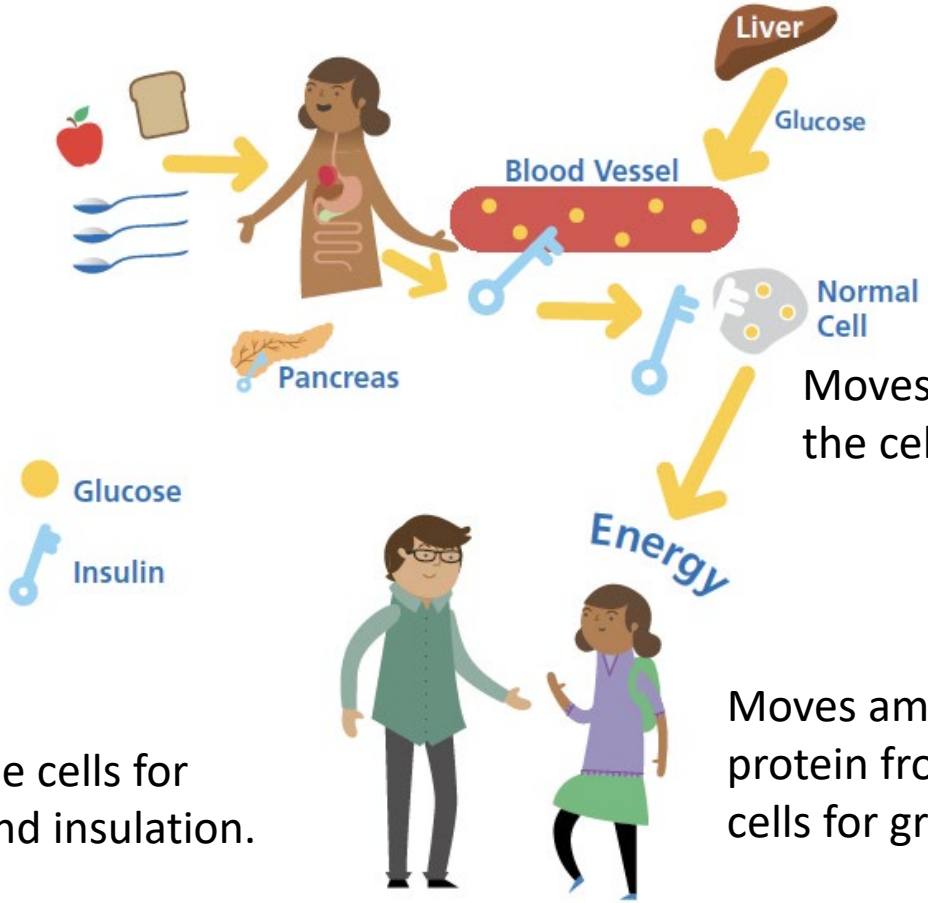

Moves glucose from blood to the cells for energy production

Moves fat into the cells for energy storage and insulation.

Moves amino acids digested from protein from the blood into the cells for growth and repair

Fast acting insulin action profile (Novorapid, Humalog, Apidra)

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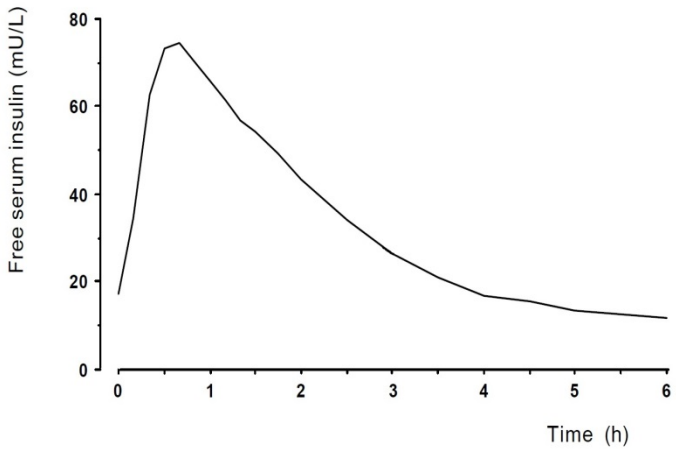
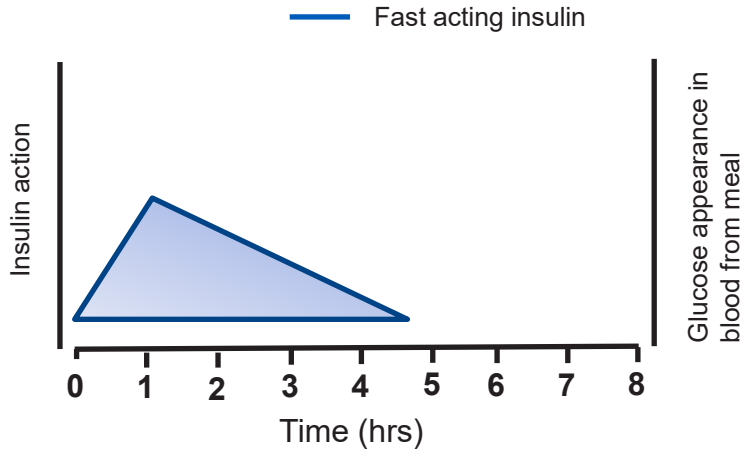
Fast acting insulin action profile





Fast acting Insulin at meal vs glucose appearance in the blood from different meals

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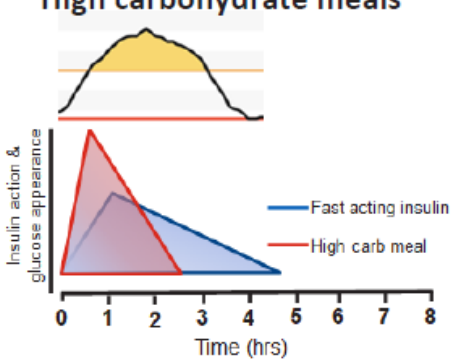
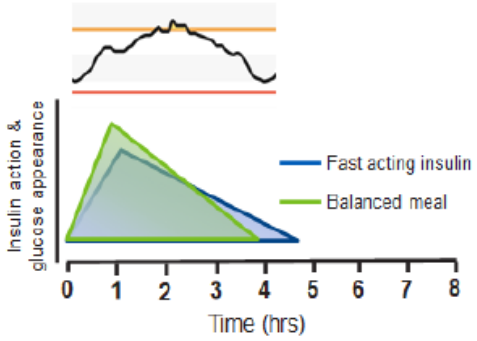
Fast acting mealtime insulin **peaks after 60-90 minutes and lasts 4-6 hours**

High carbohydrate meals



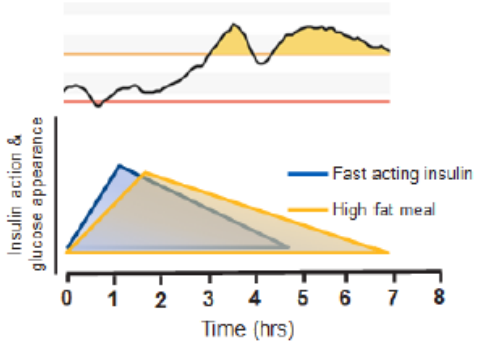
Very little fat to slow down carbohydrate absorption

Balanced meals



Just enough fat to slow down carbohydrate absorption to match insulin action

High fat meals



Too much fat slowing down carbohydrate absorption too much

This is a guide!

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- Guidance based on the AVERAGE from research:
- Each person with Type 1 diabetes is unique
- EXPECT to adjust through trial and error
- Check with your health care team before trying
- This guide is for INFORMATIONAL PURPOSES ONLY
  - Discuss and share with Diabetes Team before trying

Infographic

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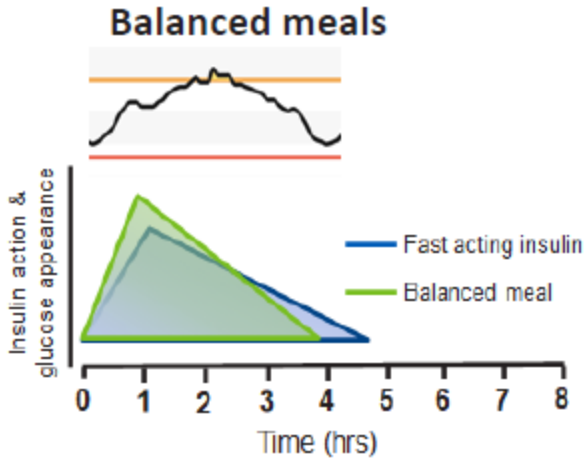

Glucose appearance peaks at 60-90 mins, lasts 4-5 hours

40-55% carbs, 20-40% fat & 10-20% protein

Breakfasts: Porridge with semi or full milk, egg on toast
Meals: Meat & potatoes & veg, jacket potato & cheese & salad
Snacks: Whole fruit with nuts, nut butter on toast, whole yoghurt

How to better match insulin to a balanced meal?

1. Count carbs (g) within 10g accuracy & use ICR
2. Normal bolus 20 minutes before eating

Balanced meals within 10g accuracy

40-55% carbs, 10-20% protein, 20-40% fat

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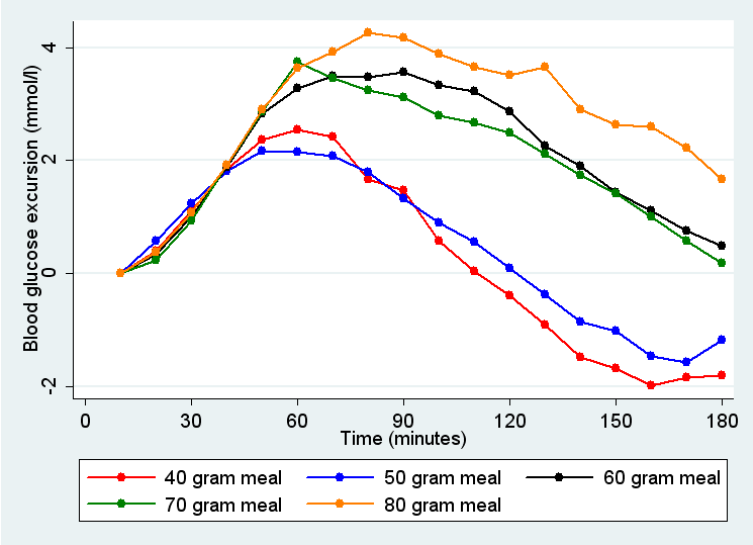
The meal was a ham sandwich with cereal bar
(55% carbs, 12% protein, 33% fat)

20g difference is too inaccurate



Diabet Med. 2012;29(7):e21-24

Why normal bolus 20 minutes before?

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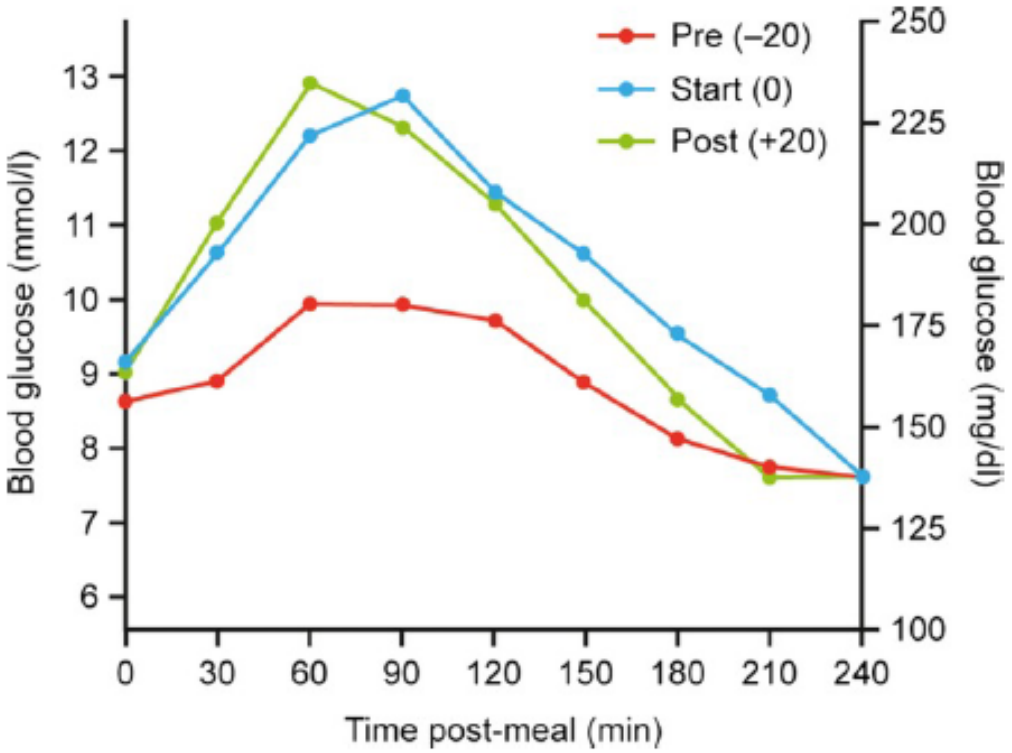

Diabetes Technol Ther. 2010;12(3):173–77.

Comprehensive review
Diabet Med. 2018;35(3):306–16.

Fast acting Insulin vs glucose appearance in the blood from a balanced meal

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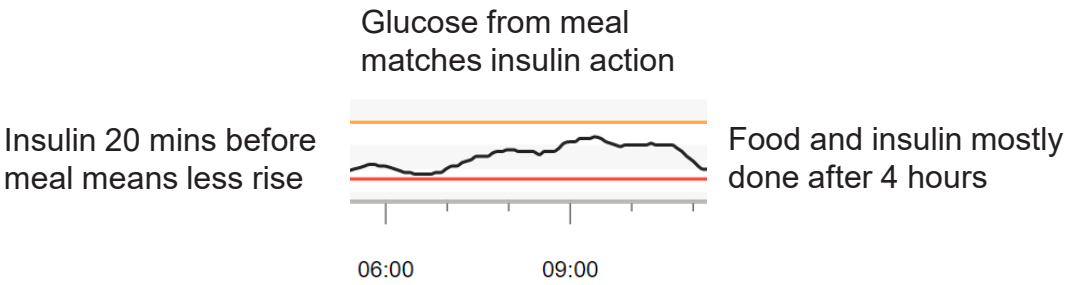
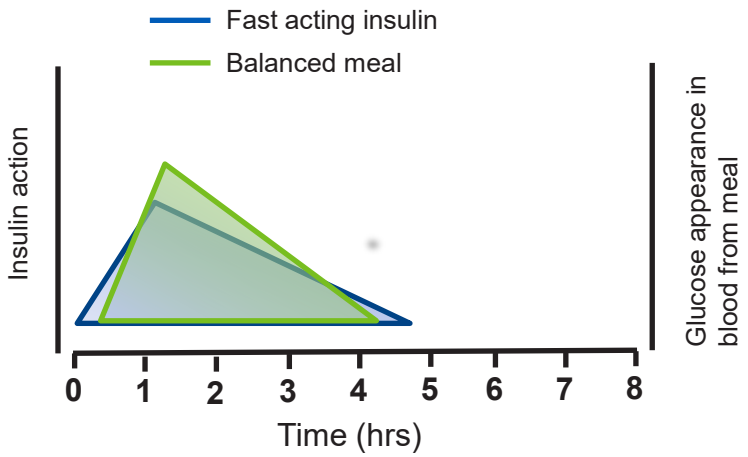
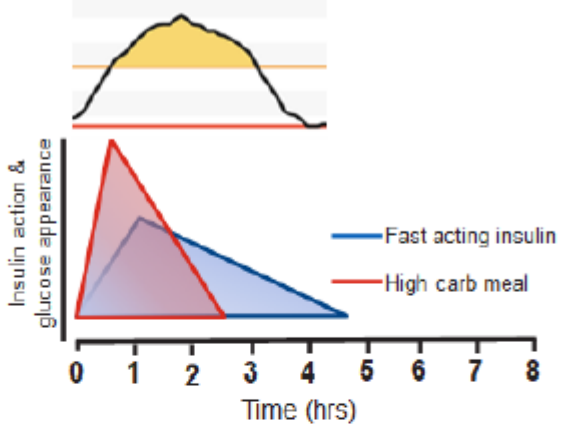




High carbohydrate meals



Glucose appearance peaks at 30-60 mins, lasts 3-4 hours

Carbs more than 55%

Breakfasts: Cereal with light milk, toast and jam, fruit bread
Meals: Jacket potato & beans, super noodles, waffles & hoops
Snacks: Cereal bars, biscuits, rice crackers, fat free yoghurt

How to better match insulin to a high carbohydrate meal?

1. Count carbs (g) within 10g accuracy & use ICR
2. Choose lower glycaemic index carb choices
3. Must be normal bolus 20 minutes before eating

Choose lower glycaemic choices or exchange some carbs for protein & fat

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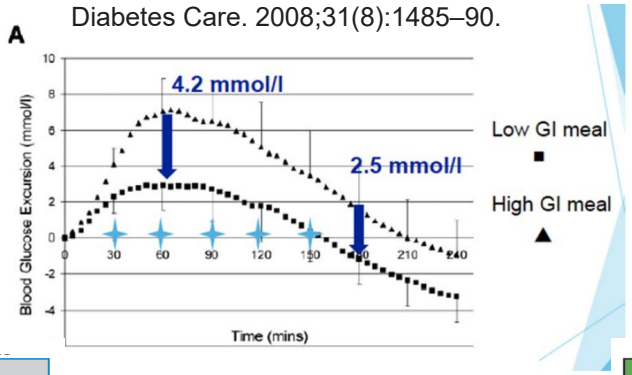
Diabetes Care. 2008;31(8):1485–90.



Meals high in carbohydrate and low in fat and protein that can make the glucose spike 1-2 hours after eating	How you exchanges some of the carbohydrate for fat and protein glucose spiking by adding fat and protein
Breakfasts	
Large Breakfast cereal with skimmed or semi skimmed milk	Medium breakfast cereal with full cream milk and a boiled egg.
Two toast with spread and jam or honey	One toast with spread and scrambled egg or mackerel or cheese spread
Croissant with Jam	Croissant with cream cheese
4 pieces of fruit	2 pieces of fruit with normal yoghurt
Lunches	
Two ham sandwich with low fat yoghurt and fruit	One cheese sandwich with full fat yoghurt
Tomato soup with 2 slices white bread and rice cakes	Tomato soup with one wholemeal bread with spread on small bag of crisps
Baked potato with spaghetti hoops	Sweet potato with spread and cheese
Evening meal	
Large white rice with curry	Basmati rice with curry and vegetables
Baked potato with beans - no spread	Baked potato with tuna mayonnaise
Mashed potato, baked beans and waffles	Mashed potato with sausages, vegetables and baked beans
Snacks	
3 Rice cakes	Small bag Corn or tortilla chips
Low fat snack bars	Nut based snack bars
Dried fruit	Nuts

Low GI cereals	Medium GI cereals	High GI cereals
All bran	Muesli (no added sugar)	Cornflakes
Oat bran	Mini wheats	Instant porridge
Porridge (whole oats)	Rolled oats	Coco Pops
Special K	Sultana bran	Weetabix
Oatibix	Shredded Wheat	Rice Krispies
Readybrek	Fruit and Fibre	Cheerios
		Bran Flakes
Low GI Breads	**Medium GI Breads**	**High GI Breads**
Sourdough bread	Oatmeal	White bread
Soya & Linseed	Pitta bread	French baguette
Granary	Wholemeal bread	Flatbread
Tortilla wrap	Chapatti	
Muffins (for toasting)	Bagel	
Low GI Starchy Foods	**Medium GI Starchy Foods**	**High GI Starchy Foods**
Pasta /Spaghetti (not overcooked)	Boiled potato	Mashed potatoes
Gluten free pasta	Sweet Potatoes	Baked potato
Cheese Tortellini	Easy cook	Thai rice (Jasmine)
Yam	American rice	Glutinous rice
Rice noodles	Wild rice	
Quinoa, pulses	Couscous	
Basmati rice		
Brown rice		

Fast acting Insulin vs glucose appearance in the blood from a high carb meal

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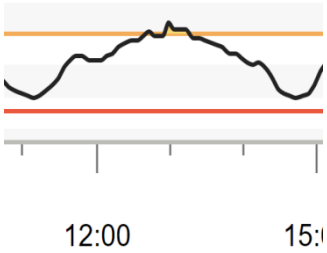
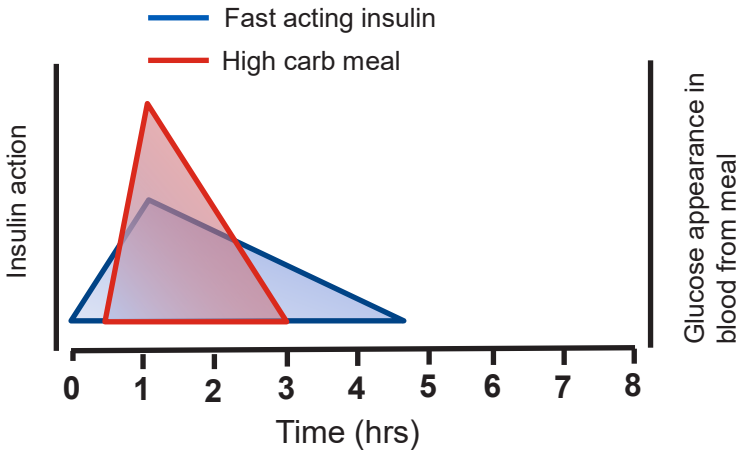
Glucose from meal is still too fast for insulin action but is much better

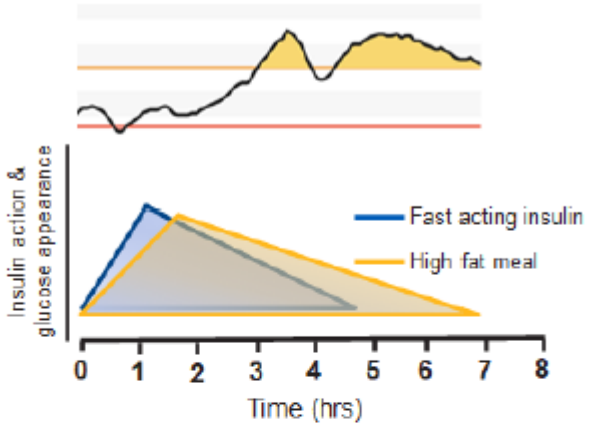
Insulin 20 mins before



Insulin catches up by 3-4 hours



High fat meals



Glucose appearance peaks at 120-180 mins, lasts 6-9 hours

Fat more than 40g with at least 30g carbs

Pizza, takeaways, creamy curry, Sunday roast, English fry-up

How to better match insulin to a high fat meal?

1. Count carbs (g) within 10g accuracy & use ICR
2. Increase insulin by 25% (may need 17-124%)
3. Pump: 50% 20 minutes before, 50% over 120 mins

   MDI: 50% 20 minutes before, 50% in 60 mins
4. KISS method to adjust extra insulin and how to split

High fat with at least 30g carb meals

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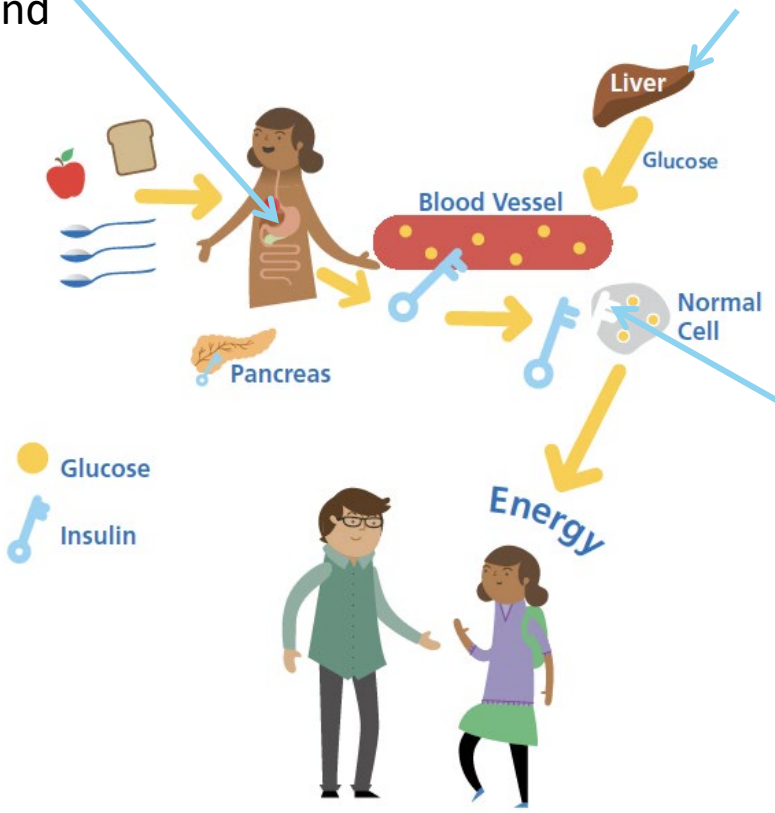
High fat meals really slows down how quickly the stomach empties and therefore the glucose appearance in blood stream.

If also high protein extra glucagon goes from the pancreas to the liver increasing glucose output



High level of fat in the blood stops the insulin working as effectively "Insulin Resistance"

The high fat Avocado on bread study

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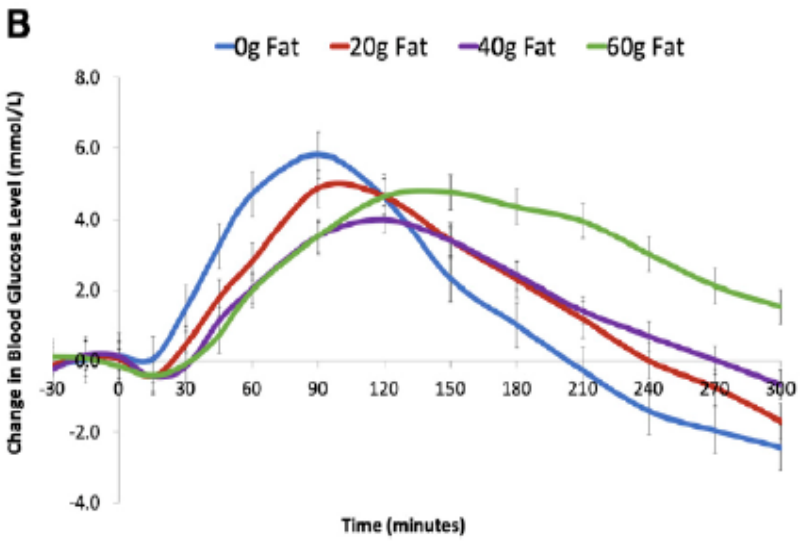
The meals two slices of bread (45g carbs):

- 0g fat = Nothing
- 20g fat = one small avocado
- 40g fat = two small avocados
- 60g fat = three small avocados



Diabetes Care. 2020;43(1):59–66

How much extra insulin was needed and what split?

- 60g fat = 21% extra 63% before, 37% over 105 min

The high fat and protein Pizza study

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The Pizza's

- LFLP Pizza = 50g carb, 9g protein, 4g fat
- HFHP Pizza = 50g carb, 36g protein, 44g fat

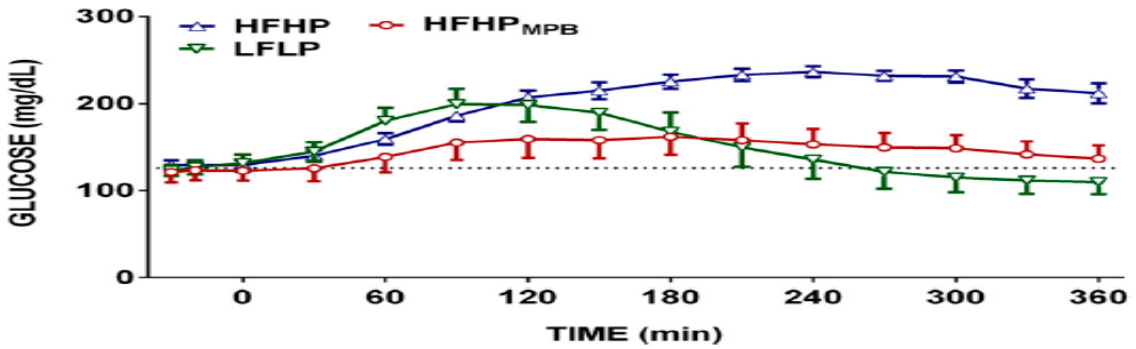

Figure 1—Postprandial plasma glucose response following LFLP and HFHP meals with identical carbohydrate content and insulin dose and an HFHP meal with optimal MPB (HFHP$_{MPB}$).

Diabetes Care 2016;39:1631–1634

How much extra insulin?

- 65% extra but varied from 17-124% extra
- Split bolus: 30% now, 70% over 150minutes

KISS
Keep it simple & safe

Endocrine Abstracts. 2018;58:P062.

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Meal	Extra Insulin	Dual wave Split
English breakfast	25% Insulin x 1.25	Pump: 50% now 50% over 2 hours MDI: 50% now, 50% in 60 minutes
Fish and Chips	25% Insulin x 1.25	Pump: 50% now 50% over 2 hours MDI: 50% now, 50% in 60 minutes
Indian Takeaway	25% Insulin x 1.25	Pump: 50% now 50% over 2 hours MDI: 50% now, 50% in 60 minutes
Pizza	25% Insulin x1.25	Pump: 50% now 50% over 2 hours MDI: 50% now, 50% in 60 minutes
Chinese Takeaway	25% Insulin x 1.25	Pump: 50% now 50% over 2 hours MDI: 50% now, 50% in 60 minutes
Pasta with creamy sauce e.g. macaroni cheese	25% Insulin x 1.25	Pump: 50% now 50% over 2 hours MDI: 50% now, 50% in 60 minutes
Fast Food meals e.g. McDonalds, KFC	25% Insulin x 1.25	Pump: 50% now 50% over 2 hours MDI: 50% now, 50% in 60 minutes

Example

- Jim is having Pepperoni Pizza with garlic bread and chicken wings which is 80g carbohydrate

- Needs 25% extra insulin spread out by a dual wave or split dose.

- Calculations for an 80g carb meal wit ICR 1u:10g
  - 80 ÷10 x = 8 units
  - 8 x 1.25 = 10units

  - Pump: 50% (5 units) now and 50% (5 units) over 2 hours

  - MDI: 50% (5 units) now and 50% (5 units) in 60 minutes time

Balance meals

Breakfasts

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High carbohydrate

Cereal & semi-skim milk

Toast with Jam

Bagel with spread

Fruit bread

Fruit & low fat yoghurt

Balanced

Porridge, nuts & semi-skim milk

Toast with egg & mushroom

Toast with fish & spinach

Bagel with cream cheese & cress

Toast & peanut butter

Fruit & full fat yoghurt

Mushroom omelette & bolied potatoes

High fat with carbohydrate

English - Fry-up

Cheese omelette & fried potatoes

Lunches

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High carbohydrate

Jacket potato & beans

Jam sandwich & biscuits

Sandwich, fruit & low fat yoghurt

Pot noodle & biscuits

Balanced

Jacket potato, cheese & salad

Sandwich, fruit & nuts

Sandwich, fruit & normal yoghurt

Pizza, salad, & fruit

Burger, salad & normal yoghurt

Pasta, meat, veg, & fruit

Rice, fish, veg & normal yoghurt

High fat with carbohydrate

Pizza, chips, & cookie

Burger, chips & crisps

Fast food takeaway

Evening meal

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High carbohydrate	Balanced	High fat with carbohydrate
Waffles & beans	Meat, potatoes & vegetables	Creamy curry, Nann bread & rice
Pot noodle & bread	Fish potatoes & vegetables	Battered fish & chips
Mash potato & beans	Dahl, rice & salad	Pizza, chips & garlic bread
	Sausage, mash potato & vegetables	Fast food takeaway
	Pasta, meat, vegetables & sauce	Cheesy pasta & garlic bread
	Omelette, salad & wedges	
	Pasta, beans & vegetables	

Snacks

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High carbohydrate

Cereal bars

Rice crackers

Toast & Jam

Fruit & low fat yoghurt

Dried fruit

Balanced

Nut based bar

Toast with peanut butter

Fruit & normal yoghurt

Dried fruit & nuts

Normal yoghurt

Cheese & crackers

High fat with carbohydrate

Crisps

Doughnuts

Large cookies

Mealtime Insulin Dosing for Type 1 Diabetes

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Balanced meals

Insulin to carbohydrate ratio (ICR) covers the insulin requirement for meals containing balanced amounts carbohydrate, protein, and fat[1].

1. **Count carbs (g) within 10g accuracy [2,3] & use ICR**
2. **Normal bolus 20 minutes before eating[14]**

Balanced meals

40-55% of total energy from carbohydrate, 20-40% from fat & 10-20% from protein[22,23].

Scrambled egg on toast: 20-30g carbs, 5-15g fat, 5-15g protein

Cheese sandwich & yogurt: 40-55g carbs, 10-25g fat, 10-25g protein

Chicken, mash potatoes & veg: 60-75g carbs, 15-35g fat, 15-35g protein

Different meals

High carb, low fat & protein

Carbs more than 55%, fat & protein less than 6g each[1]

Fruit, cereal, biscuits & bars, toast & jam, rice crackers

1. **Count carbs (g) & use ICR**
2. **Consider reducing insulin by 20%**
3. **Must be normal bolus 20 minutes before eating [24]**

High fat with at least 30g carbs

Fat more than 40g[4,5,6,7,8]

Pizza, takeaways, creamy curry, Sunday roast & pudding, English breakfast

1. **Count carbs (g) & use ICR**
2. **Increase insulin by 20-50%***
3. **Pump: 50% before, 50% over 120 mins[5], MDI: 50% before, 50% in 60 mins[6]**
4. **KISS method to adjust how much extra insulin & bolus split[21]**

*may need to increase by 17-124%[5,6,7,8]

Low carb

Carbs less then 15g

Meat & veg, eggs & mushrooms, cheese & salad

1. **Count carbs (g) & use ICR**
2. **Count protein (g) ÷ 4 & use ICR***
3. **Add calculated insulin from 1 & 2**
4. **Pump: Extended 1hr, MDI: Bolus after meal**

*estimated[9,10]

Stopping after meal glucose spikes

Nutrition tactics

Low glycaemic Index[11]

Three balanced meals[12], normal bolus 20 minutes before[14]

Limit snacking and **do not** follow:
"Eat what you like when you like, just give insulin" [13]

Insulin tactics

20 mins[14] before or DynamicGM[20]

Meal insulin into abdomen or upper arm[15]

Super bolus if on a pump[16]

Split large bolus insulin doses[17]

Activity tactics

60 mins moderate activity a day[18]

10 mins moderate activity after main meals[19]

DynamicGM short-burst of exercise if spiking 1-2 hours after eating[20]

1.Diabetes Care. 2013;36:3897–902 2. Diabet Med. 2009;26(3):279–85. 3. Diabet Med. 2012;29(7):e21-24. 4. Diabetes Care. 2013;36:810–6. 5. Diabetes Care. 2020;43(1):59–66. 6. Diabetes Vasc Dis Res. 2017;14(4):336–334. 7. Diabetes Care. 2015;38(6):1008–15. 8. Diabetes Care. 2016;39(3):1631-4 9. Diabetes. 2014;63:A15. 10. Exp Clin Endocrinol Diabetes. 2010;118(5):325–7. 11. Diabetes Care. 2008;31(8):1485–90. 12. BMJ Open Diabetes Res Care. 2019;7:e000663. 13. Pediatr Diabetes. 2018;19(4):769–75. 14. Diabet Med. 2018;35(3):306–16. 15. J Diabetes Res. 2018;1205121. 16. Journal of Diabetes Science and Technology. 2017;11(1):17. Diabetes Care. 2013;36(4):780–758. 18. Lancet Diabetes Endocrinol. 2017;5(5):377–90. 19. J Physiol. 2016;594(8):2207–22. 20. Diabetes Care. 2020; In Press. 21. Endocrine Abstracts. 2018;58:P062. 22. Pediatric Diabetes. 2018;19(27):136-154. 23. Diabetes care. 2020;43(1):S163-182. 24. BMJ Open Diabetes Research andCare 2014;2:e000050

Fast acting Insulin vs glucose appearance in the blood from a low carb meal

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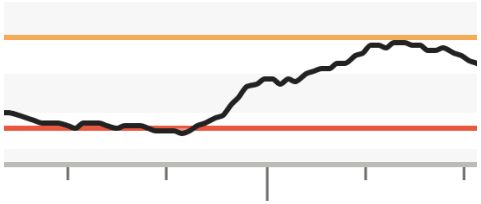
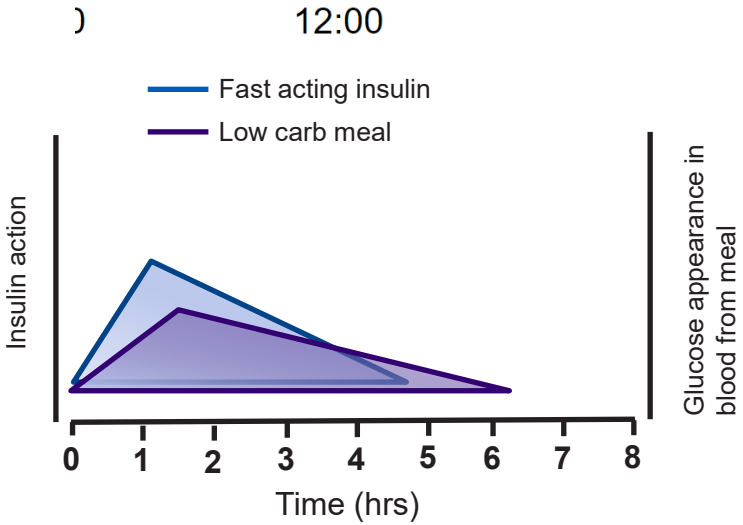
Glucose from meal is too slow for insulin action and hypos after eating

Insulin before meal can cause hypo

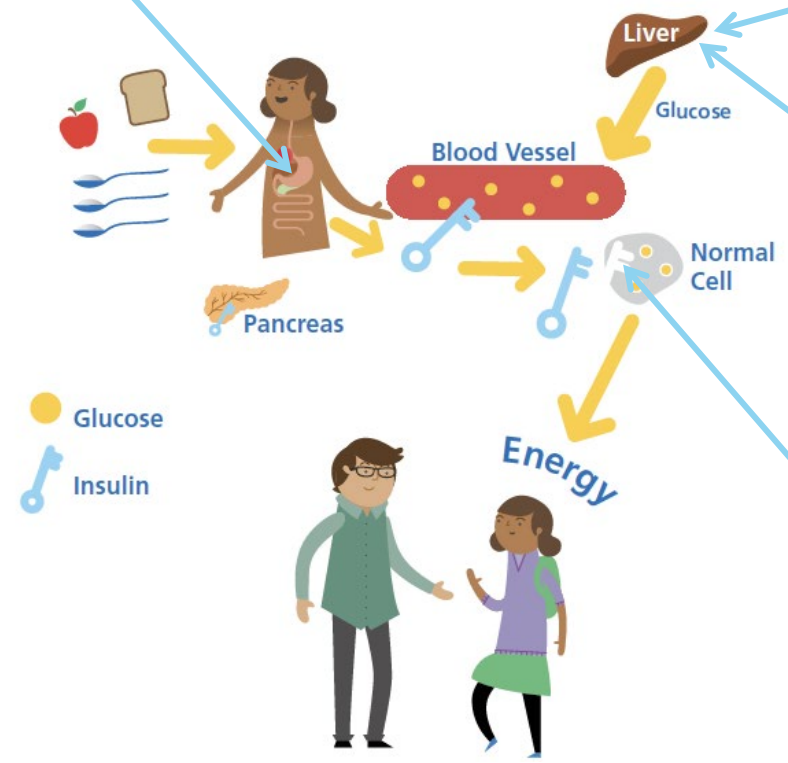


Very little insulin action left after 3 hours to match glucose appearance



Low carb meals

High fat meals slow down how quickly the stomach empties and therefore the glucose appearance in blood stream.



High protein increases Glucagon in the first 2 hours after eating pushing glucose out of the liver.

Excess protein increases new glucose made by the liver after 3 hours.

High level of fat in the blood stops the insulin working as effectively "Insulin resistance"

Require insulin to cover Low carb meals

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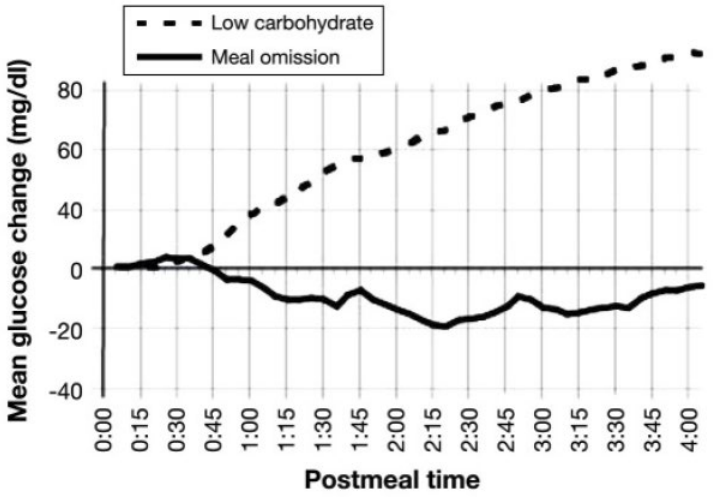
Low carbohydrate meal

- 2.5g carb, 32.4g protein, 52.0g fat



Exp Clin Endocrinol Diabetes. 2010;118(5):325–7

Small amount f insulin to cover Low carb meals

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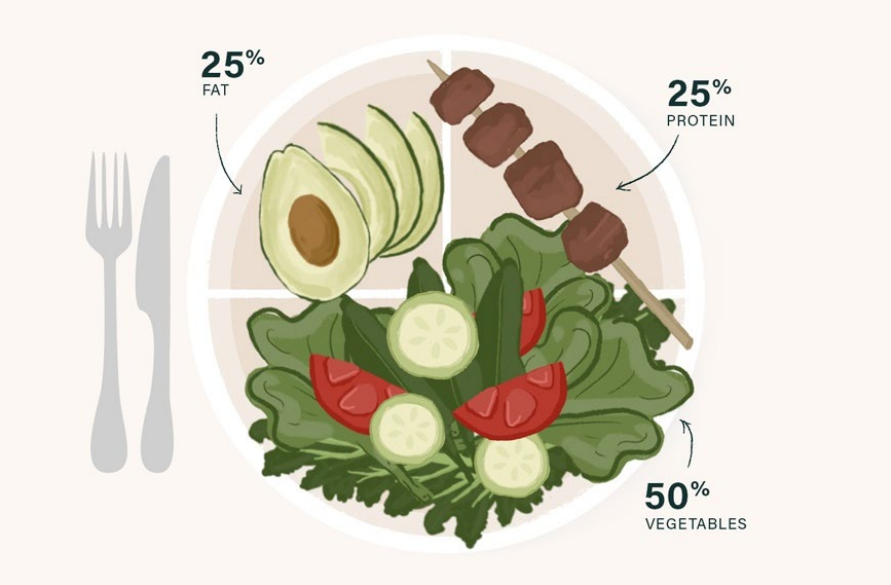

Low carb example

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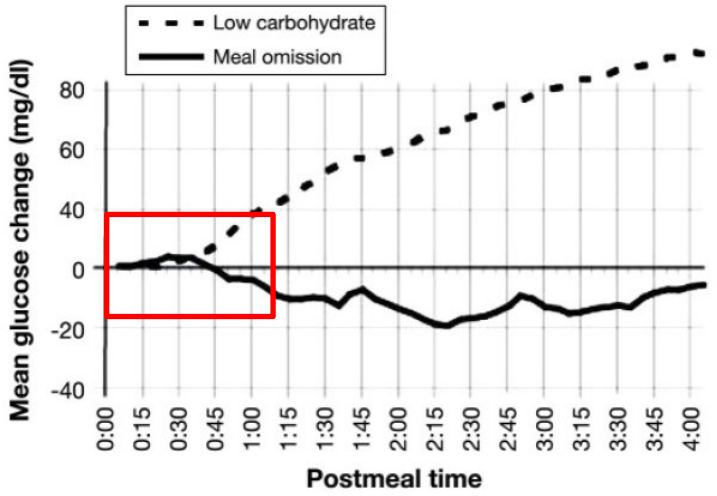
- Jim is eating a steak, green leafy vegetables, olive oil and hummus
  - 40g protein
  - 10g carbs
  - 30g fat
- Calculating insulin with an ICR if 1u:10g
  - Carbs 10g ÷ 10 = 1 unit
  - Protein 40g ÷ 4 = 10 ÷ 10 = 1units
  - Carbs insulin 1unit + protein insulin 1units = 2 units
  - How to deliver:
    - Pump: Extended wave over 1 hour
    - MDI: After eating
- Adjust timing and amount based on experience



Fast acting Insulin vs glucose appearance in the blood from a low carb meal

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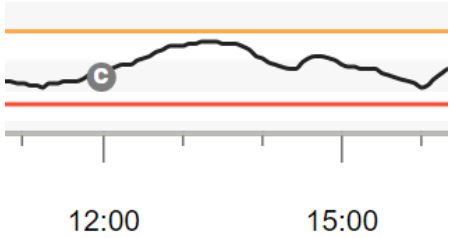
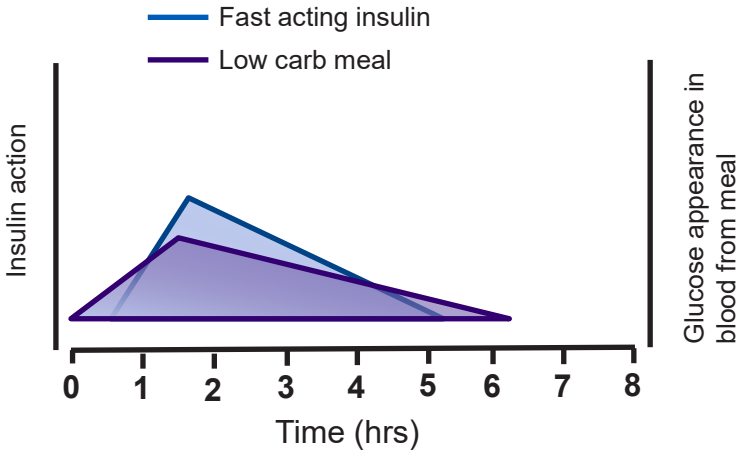
Glucose from meal better matched insulin action

Insulin after meal prevents going hypo



More insulin 3-5 hours after eating to match glucose appearance from low carb meal



Stopping after meal glucose spikes

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Nutrition tactics

Three balanced whole food meals with minimal snacks

Do not follow:
"Eat what you like, when you like, just give insulin"

Low glycaemic index carb choices

Insulin tactics

Insulin 20 mins before meal

Meal insulin into abdomen or upper arm not leg or buttocks

Avoid lumpy injection sites and rotate injection/cannula sites

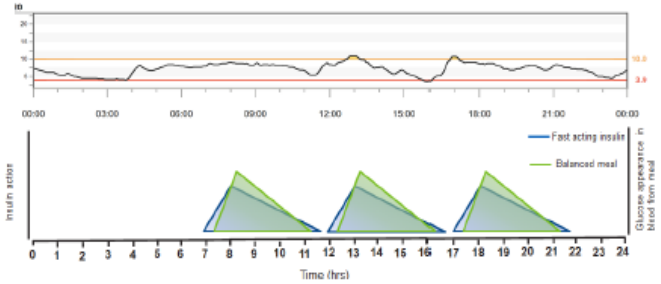
Activity tactics

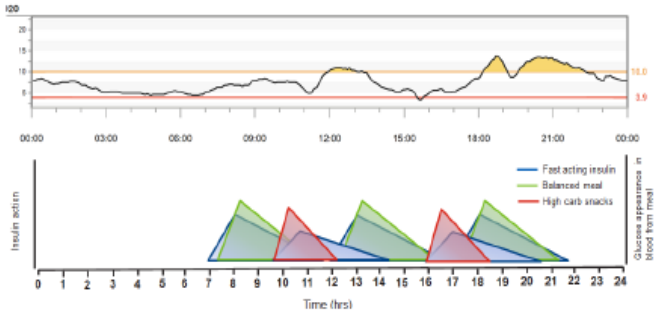
60 mins moderate activity a day, try three 20 minutes:

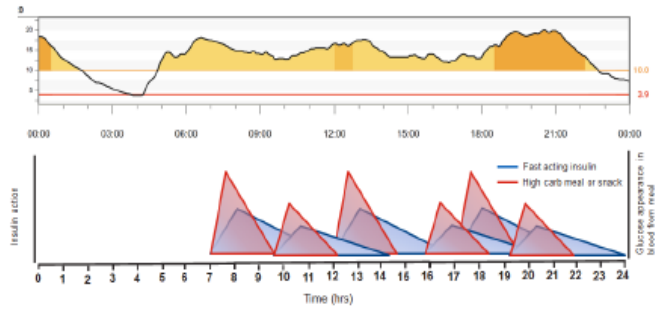
"Opens a side door to muscle cells to let more glucose in"

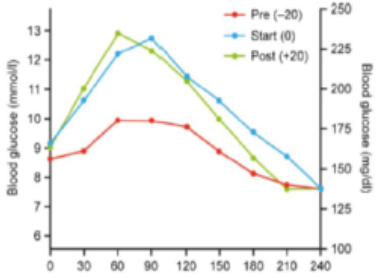
10 mins of moderate activity after meals:

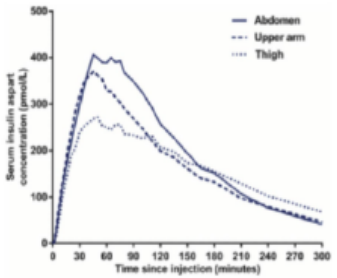
"Gets insulin to the muscles faster to speed up its action"

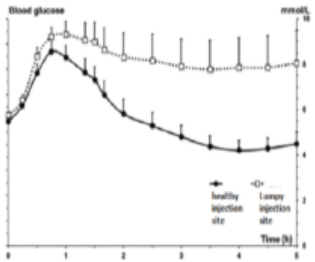




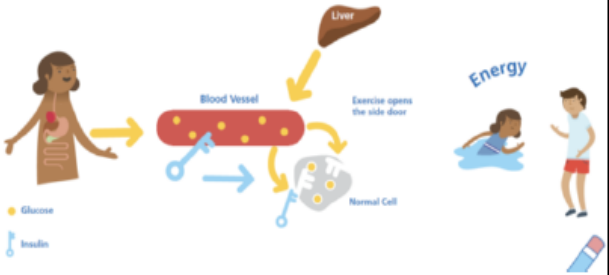


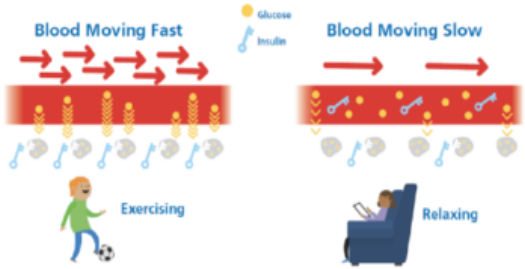






Low to moderate intensity activity:
walking, playing in the playground, jogging, shopping





Keep it simple, do 10 minutes of moderate activity after each meal to stop glucose spikes!

Walking the talk

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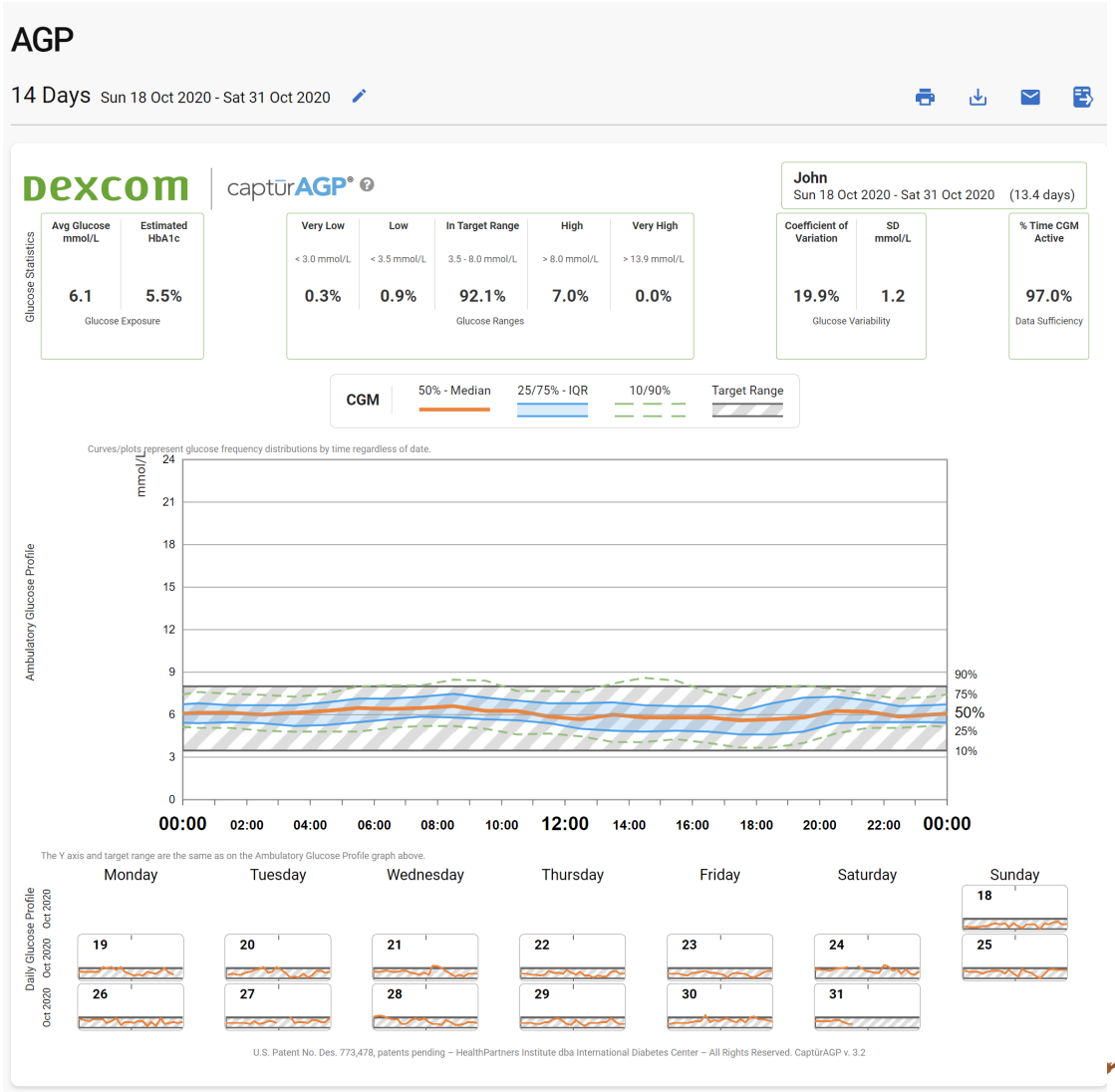

Will you adopt any of?

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- Normal is not natural (proven over millions of years of evolution)?
  - ***Would my great grandmother recognise it as food?***

- Do I have skin in the game - Monkey (Grace & Jude) see monkey do
  - ***Am I walking the talk?***

- Does my food environment betray my intentions?
  - **Are my cupboards, fridge and lunchbox filled with normal or natural food?**

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Mealtime Insulin Dosing for Type 1 Diabetes

John Pemberton
Diabetes Dietitian
Type 1 D since 2008
johnpemberton@nhs.net
(I may not reply as my kids come first, but I will if I can)