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Optimising Mealtime Insulin Dosing:

Do Protein & Fat Matter?

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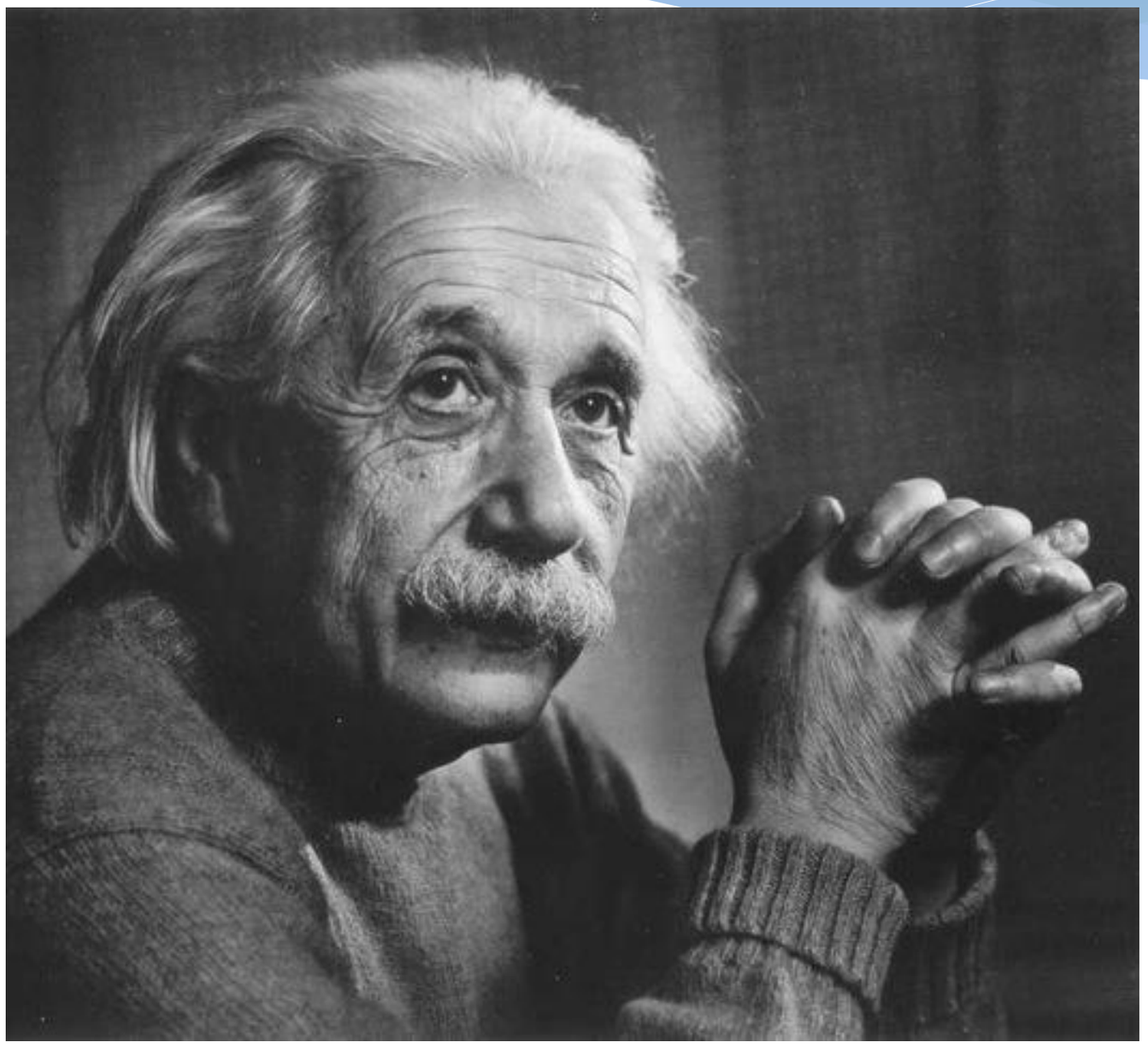
“Not everything that can be counted counts, and not everything that counts can be counted”

Albert Einstein



Overview

* Carbohydrate Counting
* Effects of Protein & Fat
* Clinical Application
* Food Insulin Index (FII)

Estimating Mealtime Insulin Dose in Type 1 Diabetes

Carbohydrate Counting

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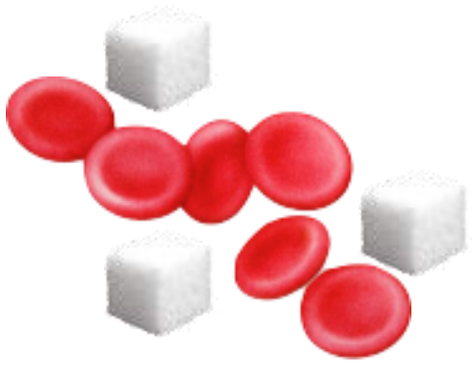
Glycaemic Response



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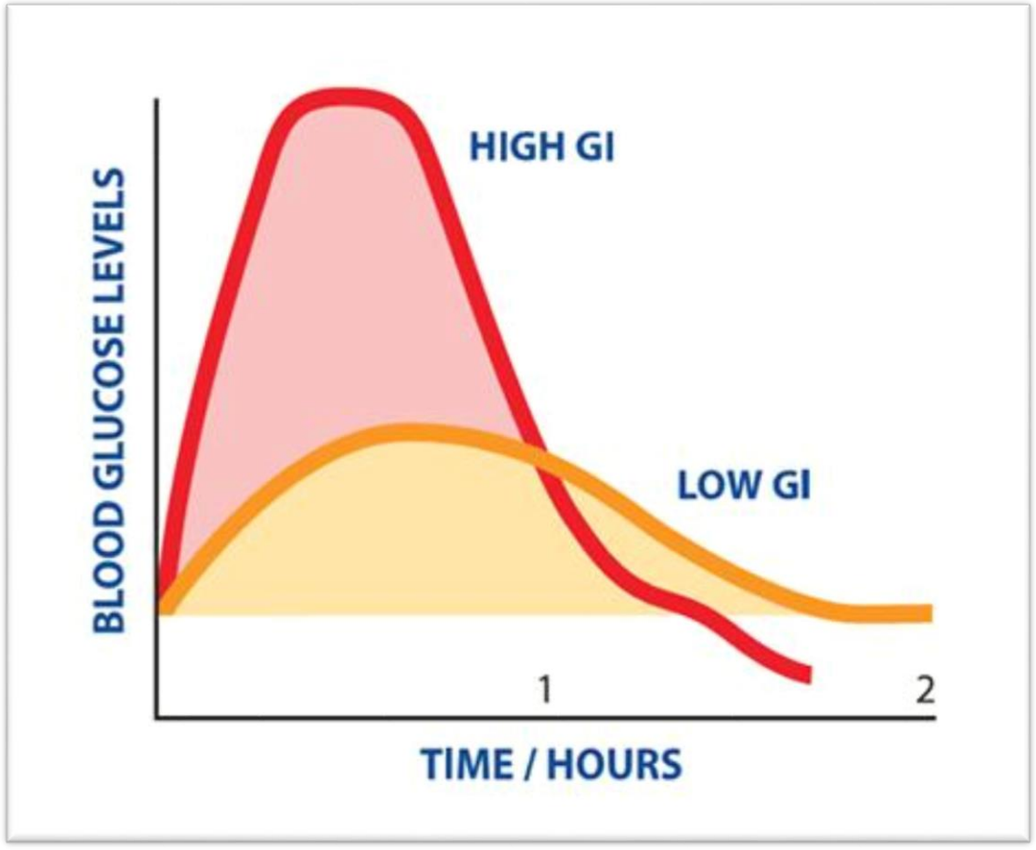
Bolus Insulin Dose

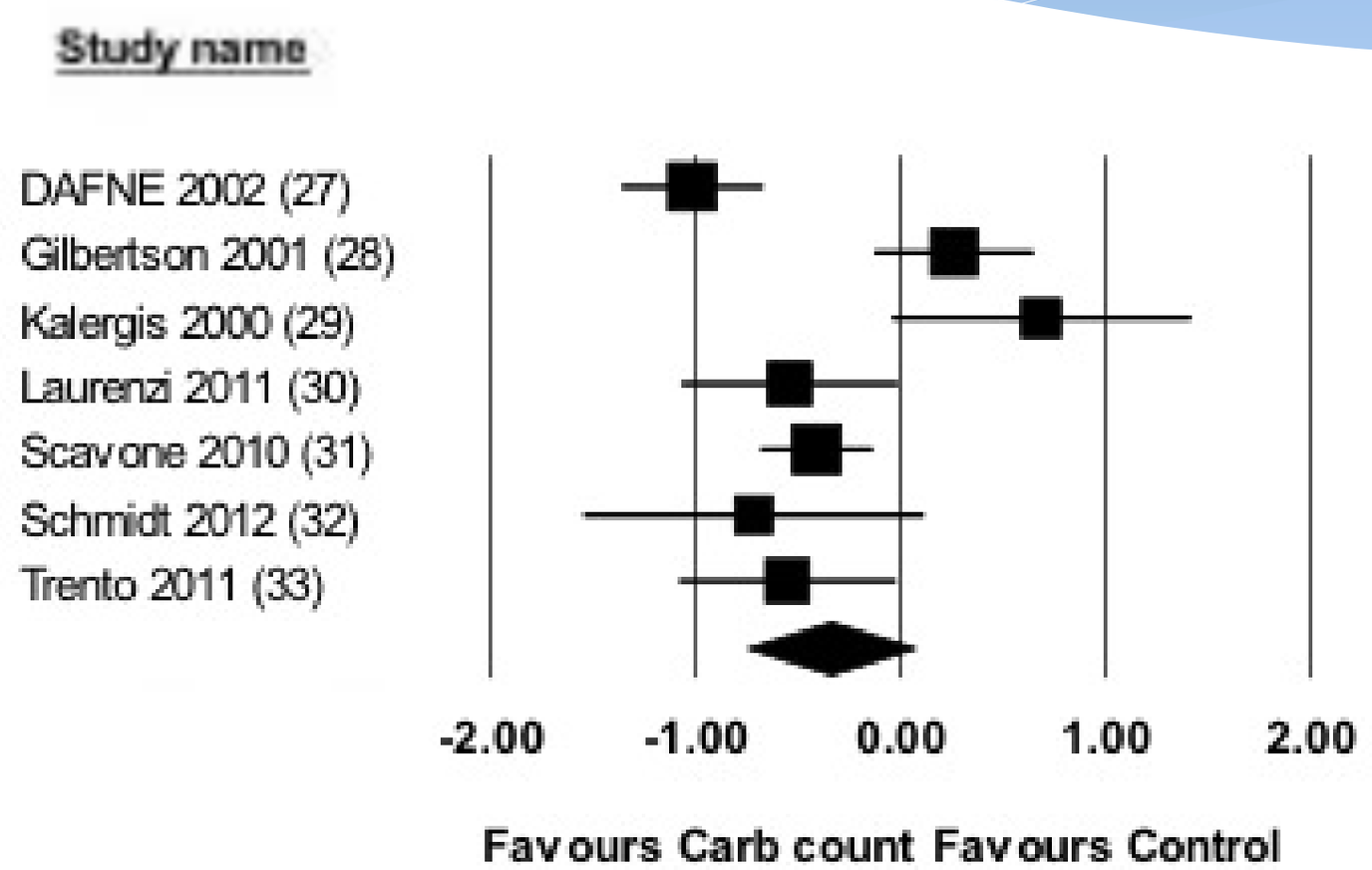
Limitations of Carb Counting

* Carbohydrates don't affect blood glucose levels equally (Glycemic Index)

* Evidence for the efficacy of carbohydrate counting is limited



Carbohydrate Counting Does Not Significantly Improve HbA1c



Overall change in HbA1c -0.35% points (p = 0.096)

Bell et al, Lancet Diab & Endo 2014; 2(2): 133-140

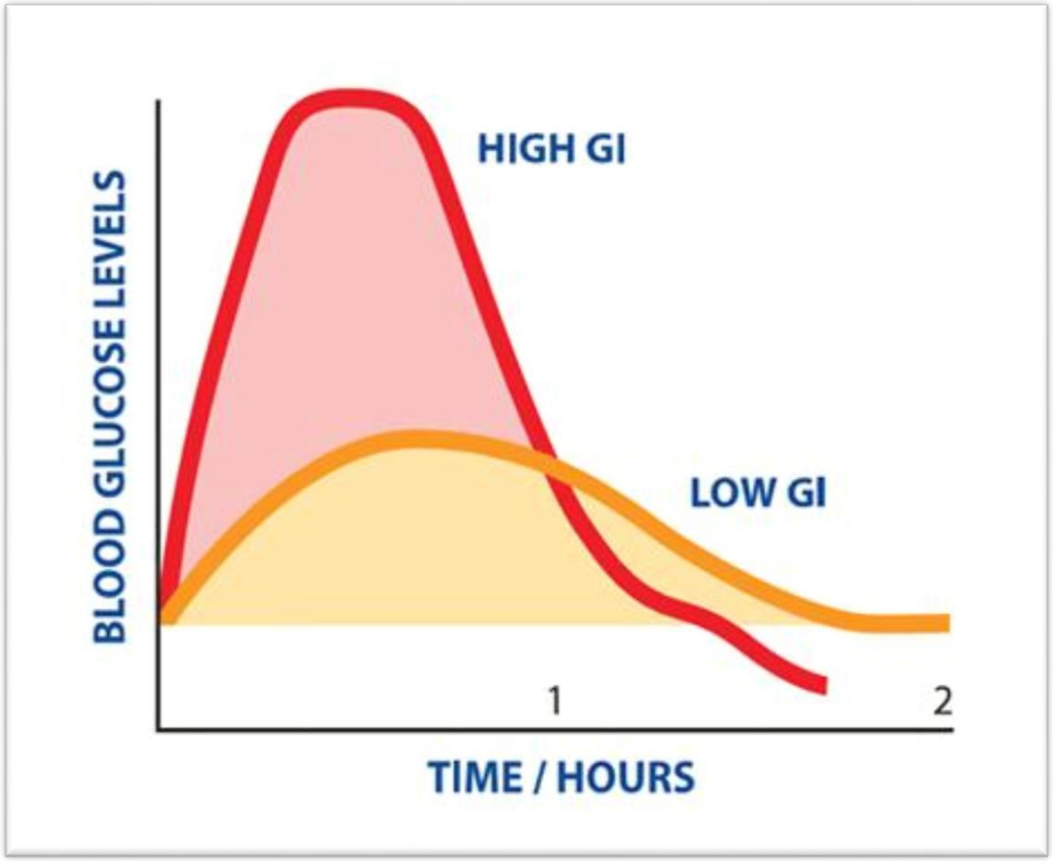
Limitations of Carb Counting

* Carbohydrates don't affect blood glucose levels equally (Glycemic Index)

* Evidence for the efficacy of carbohydrate counting is limited

* Treating Symptoms vs. Cause

* Stimulation of insulin secretion is multifactorial



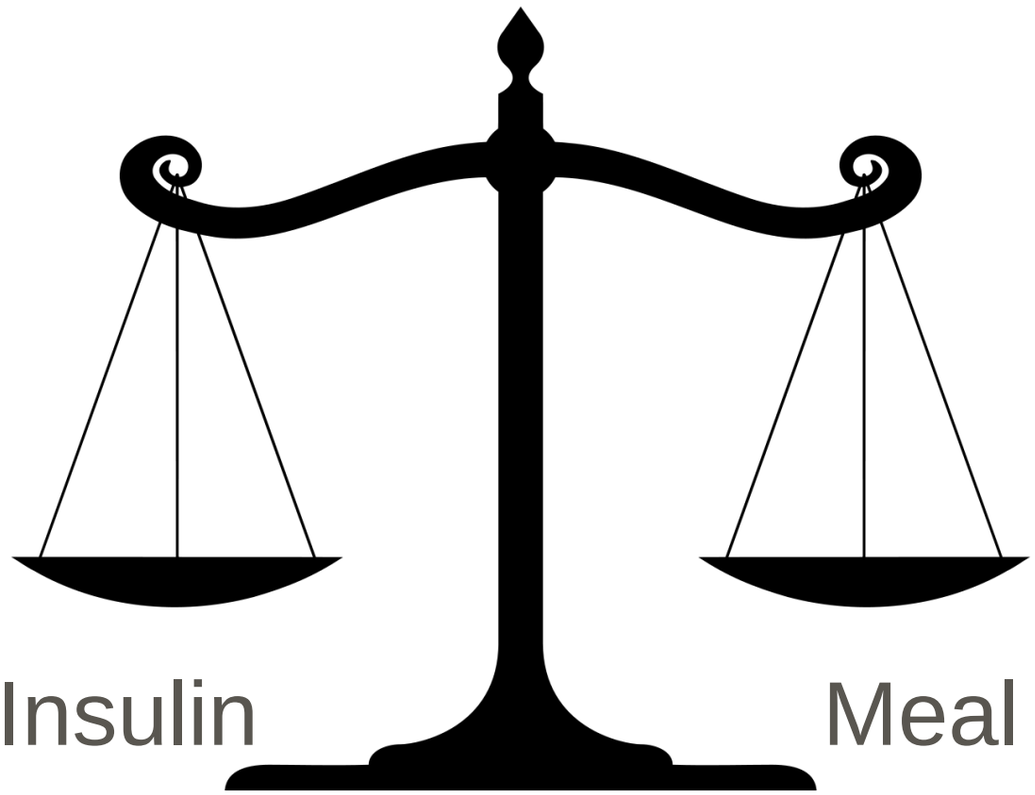
Do Protein and Fat Affect Blood Glucose Levels?

Healthy Subjects

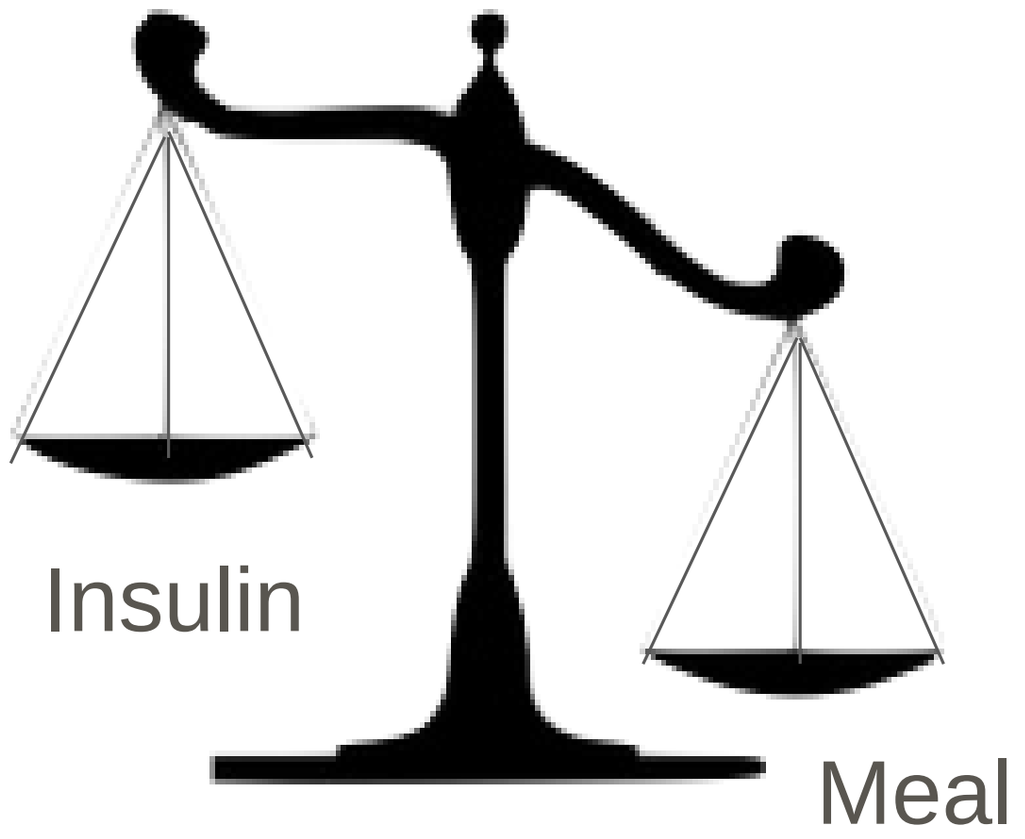
* Insulin is an anabolic hormone, involved in the storage of glucose, amino acids and fatty acids
* Minimal effect on BG in healthy subjects
* Protein can cause a significant insulin response
* Fat in isolation does not initiate insulin release but amplifies glucose-stimulated insulin release
* Fat also increases insulin resistance

Type 1 Diabetes

Normal BGL

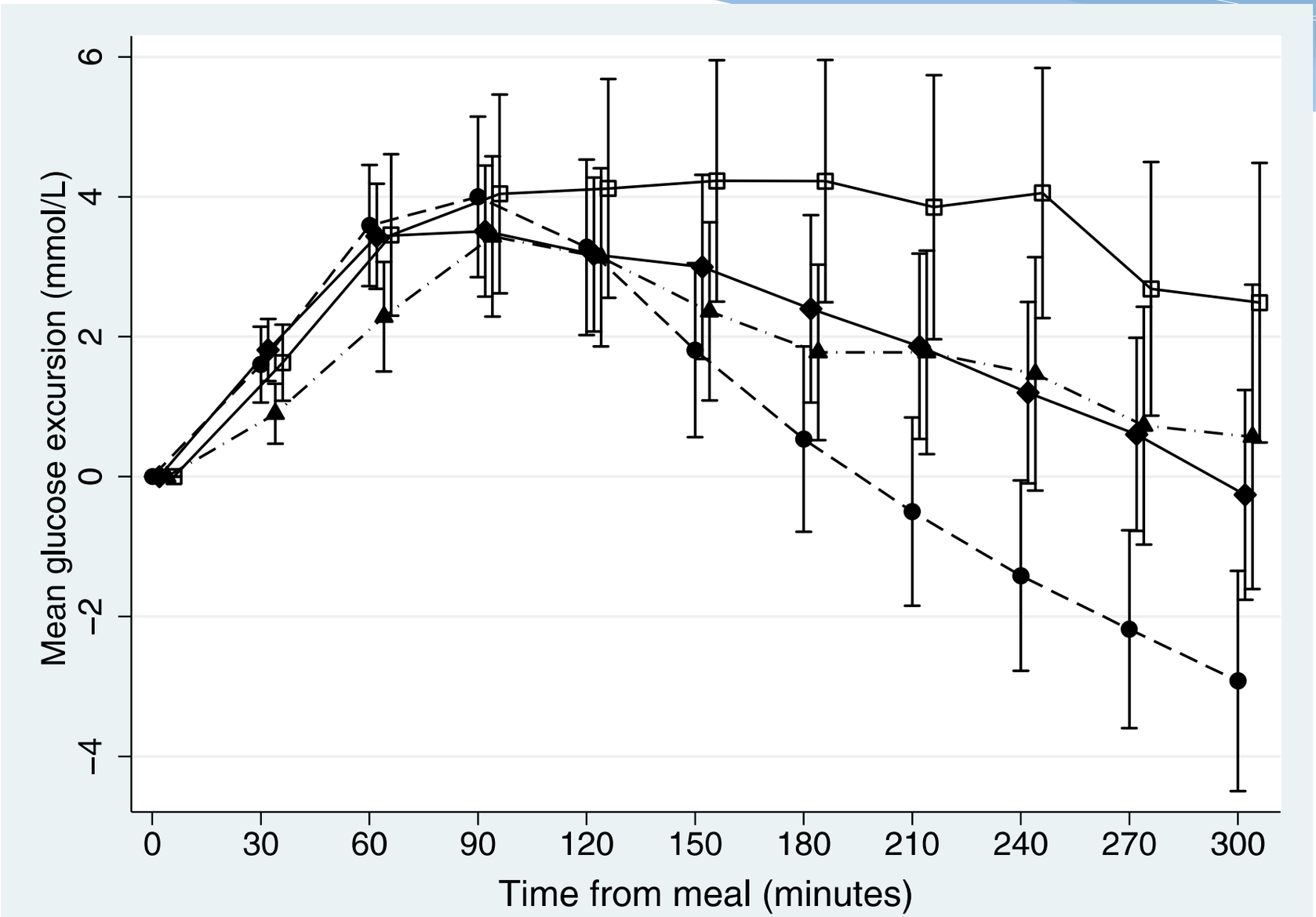


Elevated BGL



- Increased hepatic glucose output

Fat and Protein Increase Insulin Requirements



Fat & Protein (HF/HP)

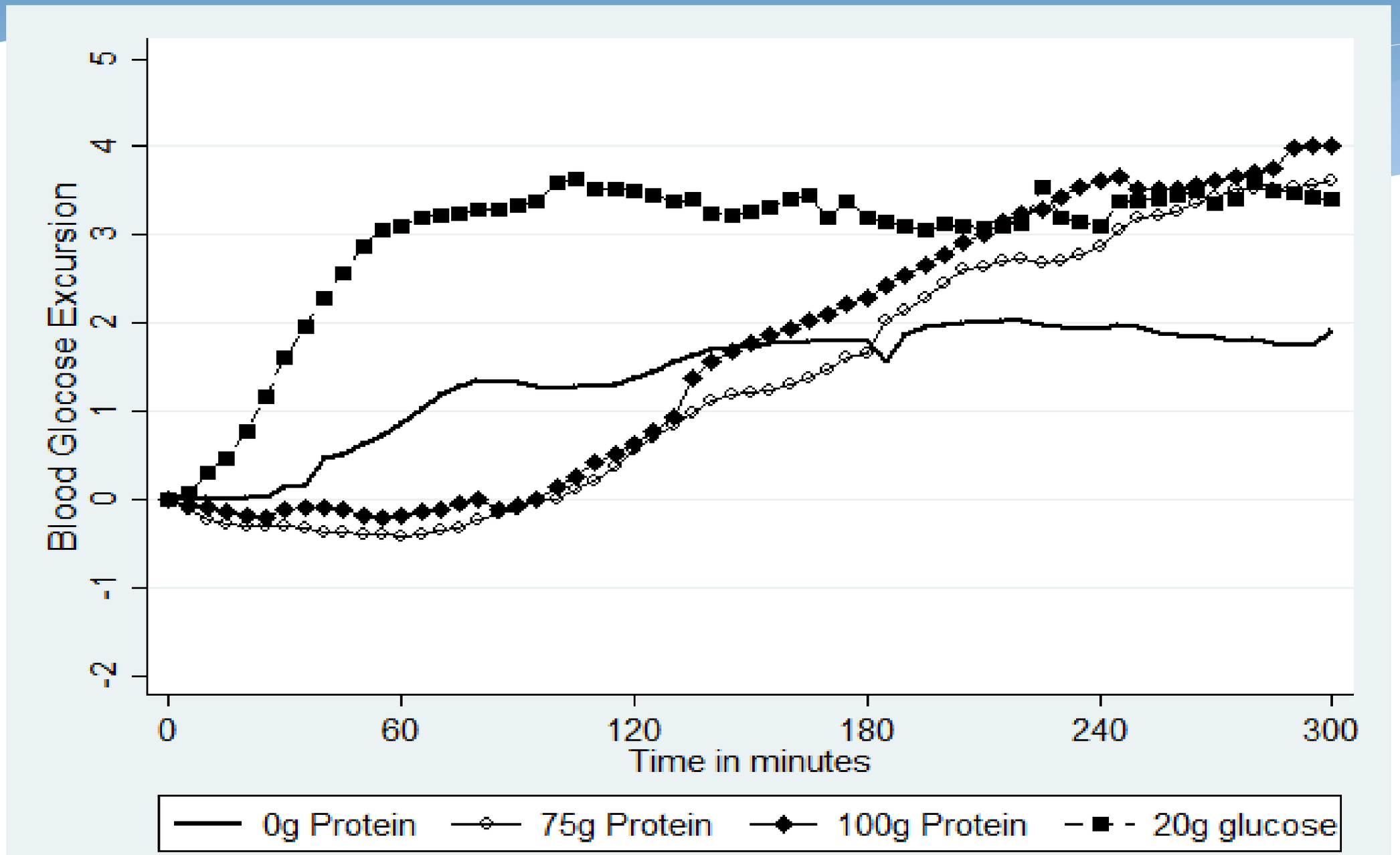
Fat (HF/LP)

Protein (LF/HP)

CHO (LF/LP)

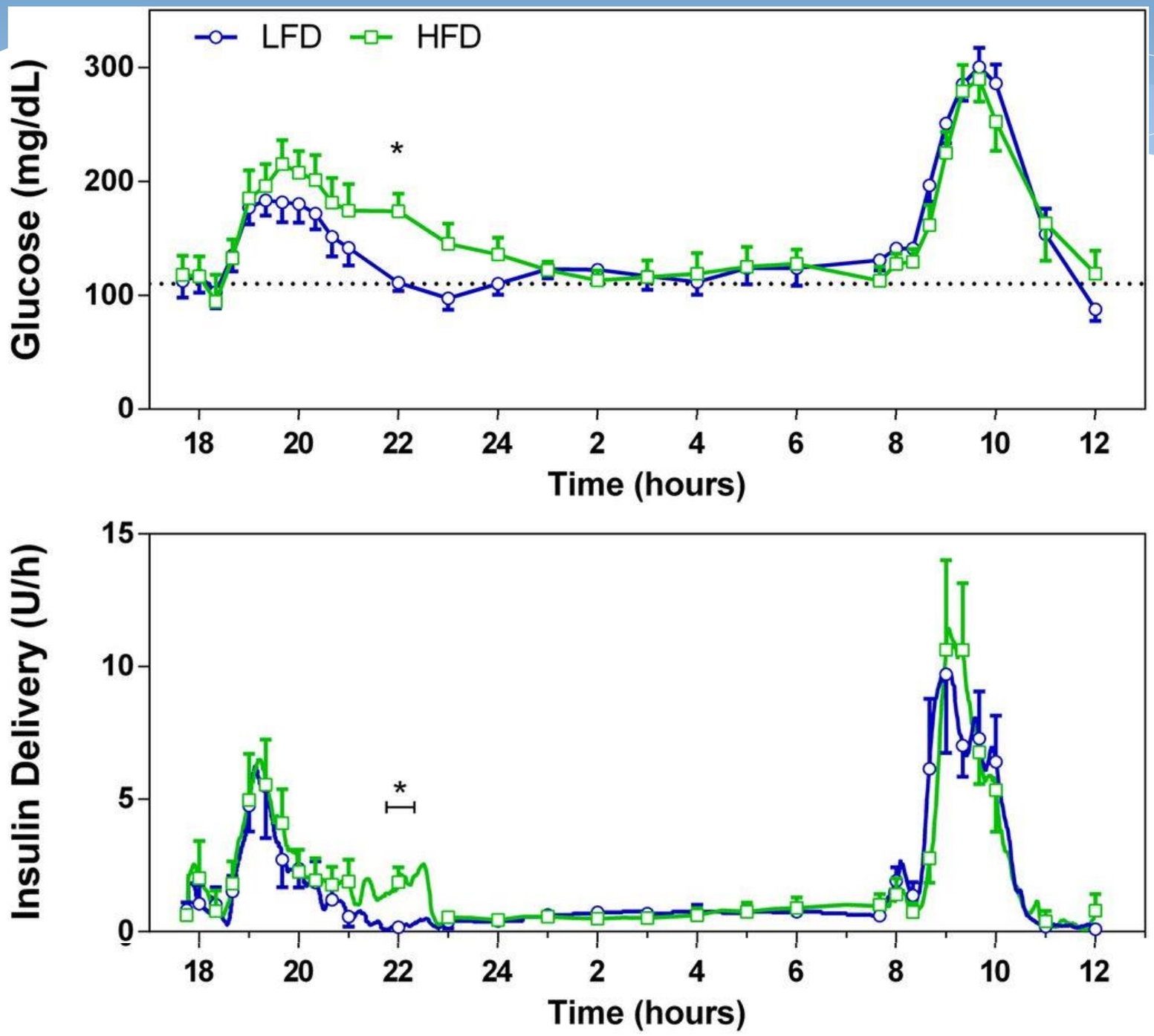
Smart et al. Diabetes Care 2013; 36: 3897-3902

Pure Protein Increases BG



Paterson et al. Diabetes 2014;63(S1):A15

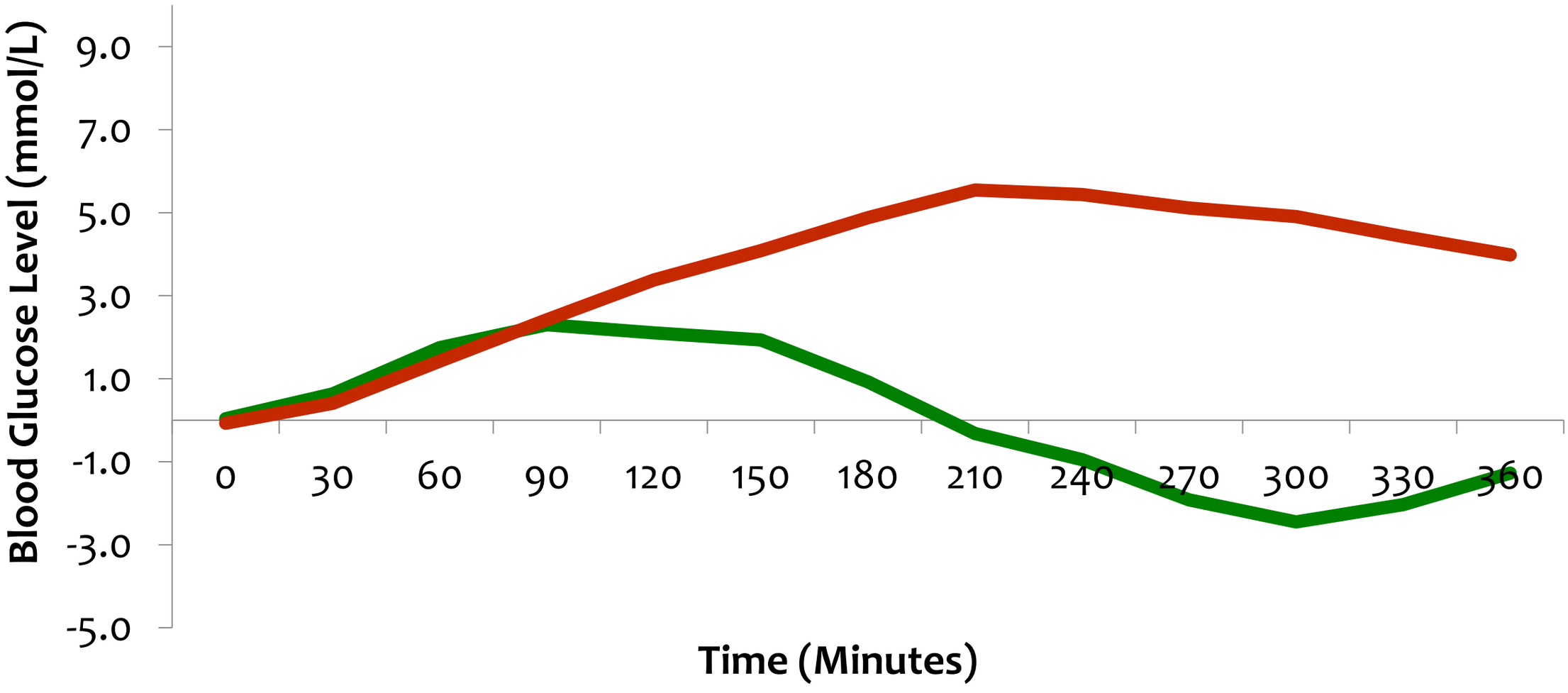
Dietary Fat Increases BGL and Insulin Requirements



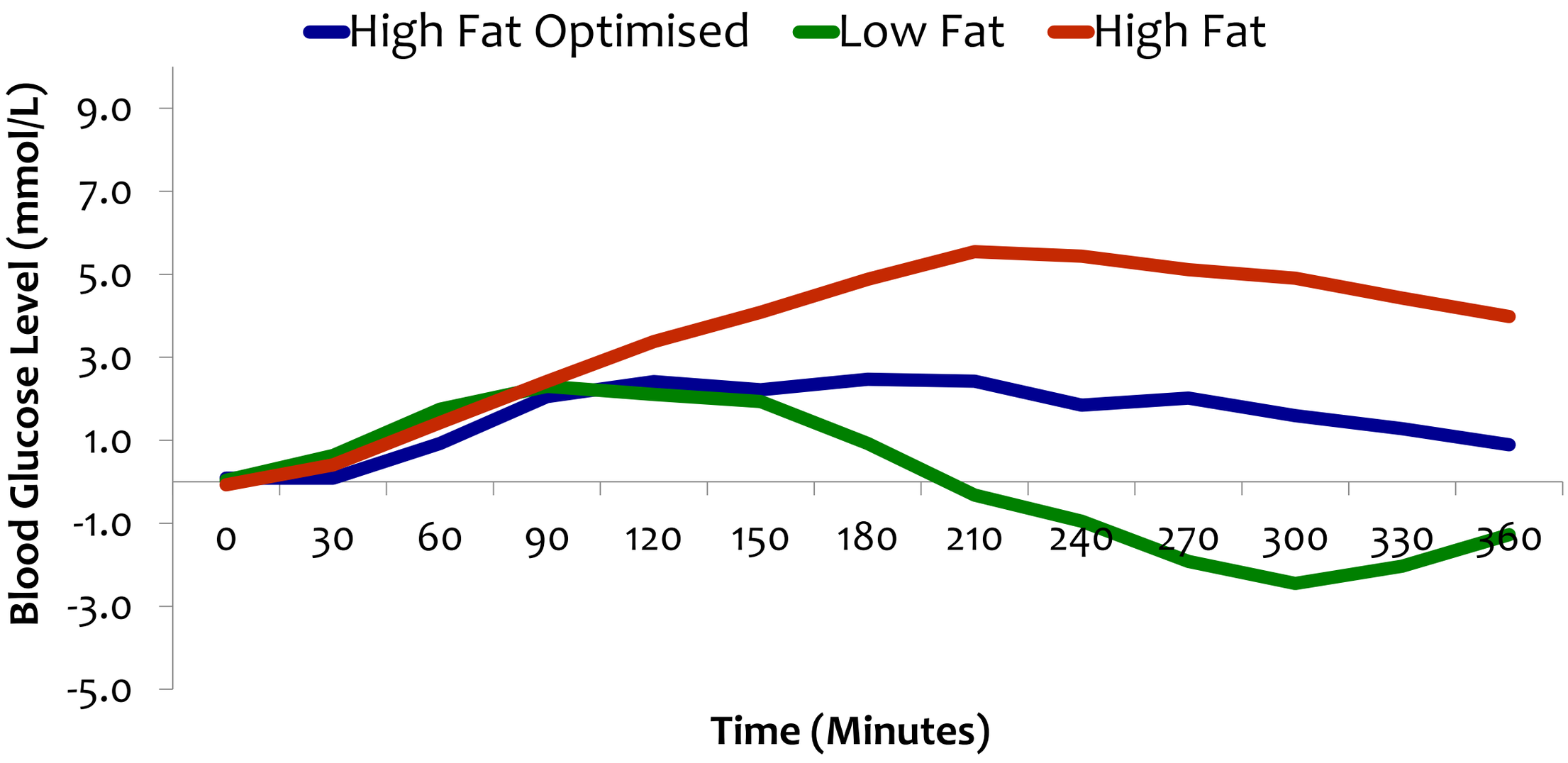
High Fat vs Low Fat Dinner on postprandial BGL using closed loop insulin delivery

Wolpert et al. Diabetes Care 2013;36:810-816

Adding 40g Fat Increases Postprandial Glycaemia



75% More Insulin Required
Dual Wave: 30/70% over 2.5hr



Dietary Fat

* Seven RCT (103 patients)
* All studies showed dietary fat influenced glycaemia
* Reduces early postprandial glucose rise (first 2-3h)
* Delays peak glucose level
* Leads to late postprandial hyperglycaemia (≥ 3h)
* High fat meals (≥ 35g of fat) requires insulin adjustment

Bell et al. Diabetes Care 2015; 38:1008-1015

Dietary Protein

* Seven RCT (125 patients)
* All studies showed dietary protein influenced glycaemia
* Delayed effect on glycaemia (>100 mins)
* Different effect with and without carbohydrate

* Insulin adjustment needed for:
  - ≥ 30g protein with carbs
  - ≥ 75g protein alone

Bell et al. Diabetes Care 2015; 38:1008-1015

Adjusting Insulin for Protein & Fat

* Insulin doses need to be adjusted for high protein and fat meals
* Advanced tools for intensive therapy – not for all patients

* Not clear how insulin dose should be calculated, ideal timing for dosing and insulin delivery patterns
* Need to consider overall diet – adjusting meal timing, routine and composition may be more effective

Can We Do Better?

Protein & Fat Counting

* Warsaw School of Insulin Pump Therapy have developed a novel algorithm to calculate the total insulin dose needed to cover carbohydrate plus protein & fat.
* Fat and Protein is counted together as a 'Fat and Protein Unit (FPU)', where 1 FPU = 100kCal of fat and/or protein.
* How to dose insulin:
  1. Normal wave bolus for carbohydrate using usual ICR
  2. Dual or square wave bolus for FPU using same ICR and run over 3-8hr depending on number of FPU

Pankowska et al Pediatric Diabetes 2009; 10(5): 298-303.

Estimating Mealtime Insulin Dose in Type 1 Diabetes

Current Thinking

Carbohydrate Counting

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Glycaemic Response

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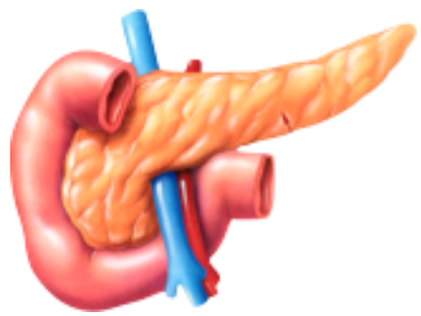
Bolus Insulin Dose

Novel Thinking



Insulin Response in Healthy Individuals

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Insulin Demand

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Bolus Insulin Dose

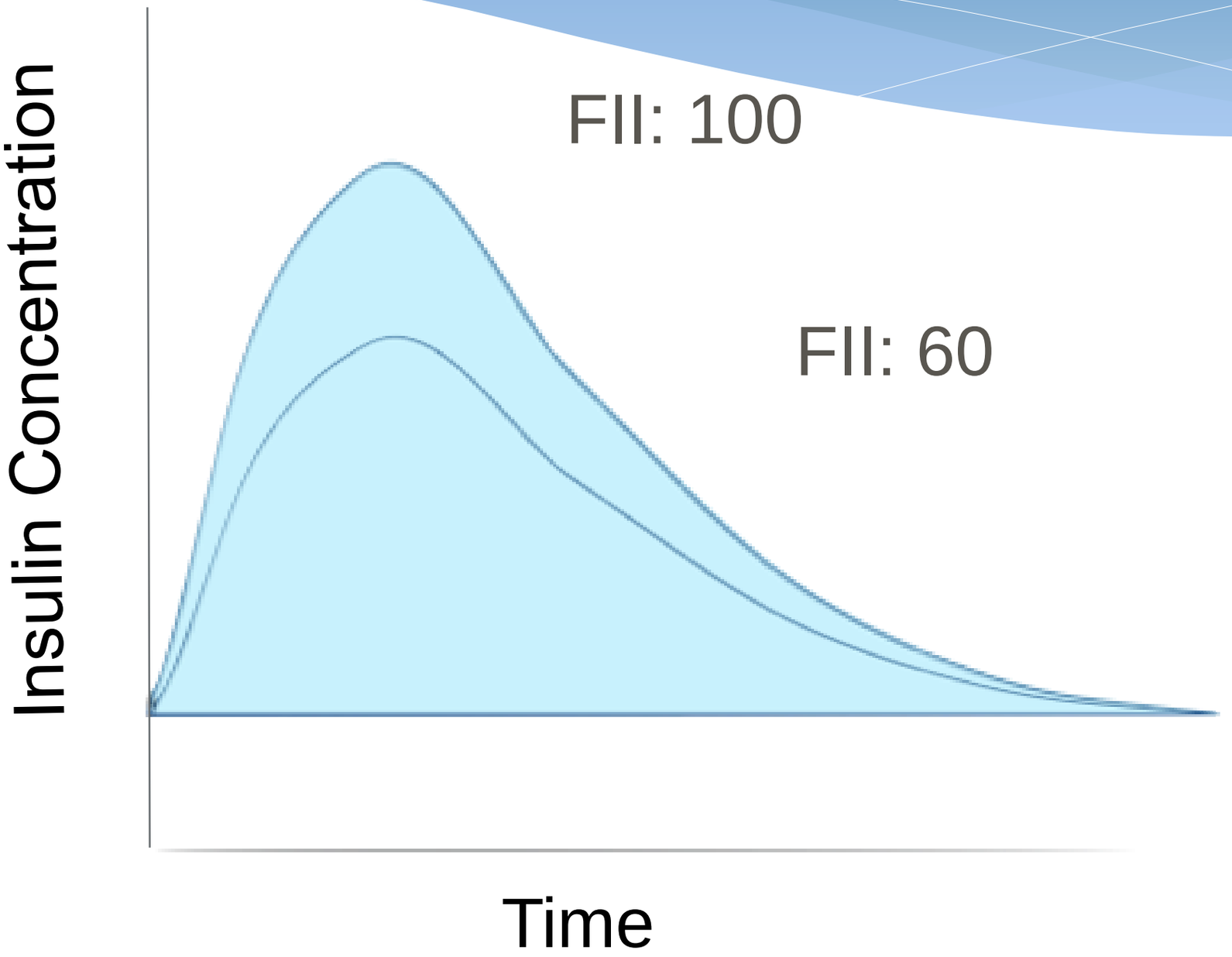
Food Insulin Index (FII)

* Relative measure of the normal insulin demand of a food
* Insulin response measured in healthy adults
* Foods measured in 1000kJ portions
* Relative to a reference food

$$FII = \frac{120min\ AUC_{Insulin}\ for\ 1000kJ\ of\ test\ food}{120min\ AUC_{Insulin}\ for\ 1000kJ\ of\ ref.\ food} \times 100$$

Bao et al. Am J Clin Nutr 2011; 93:984–96.

Calculating the AUC



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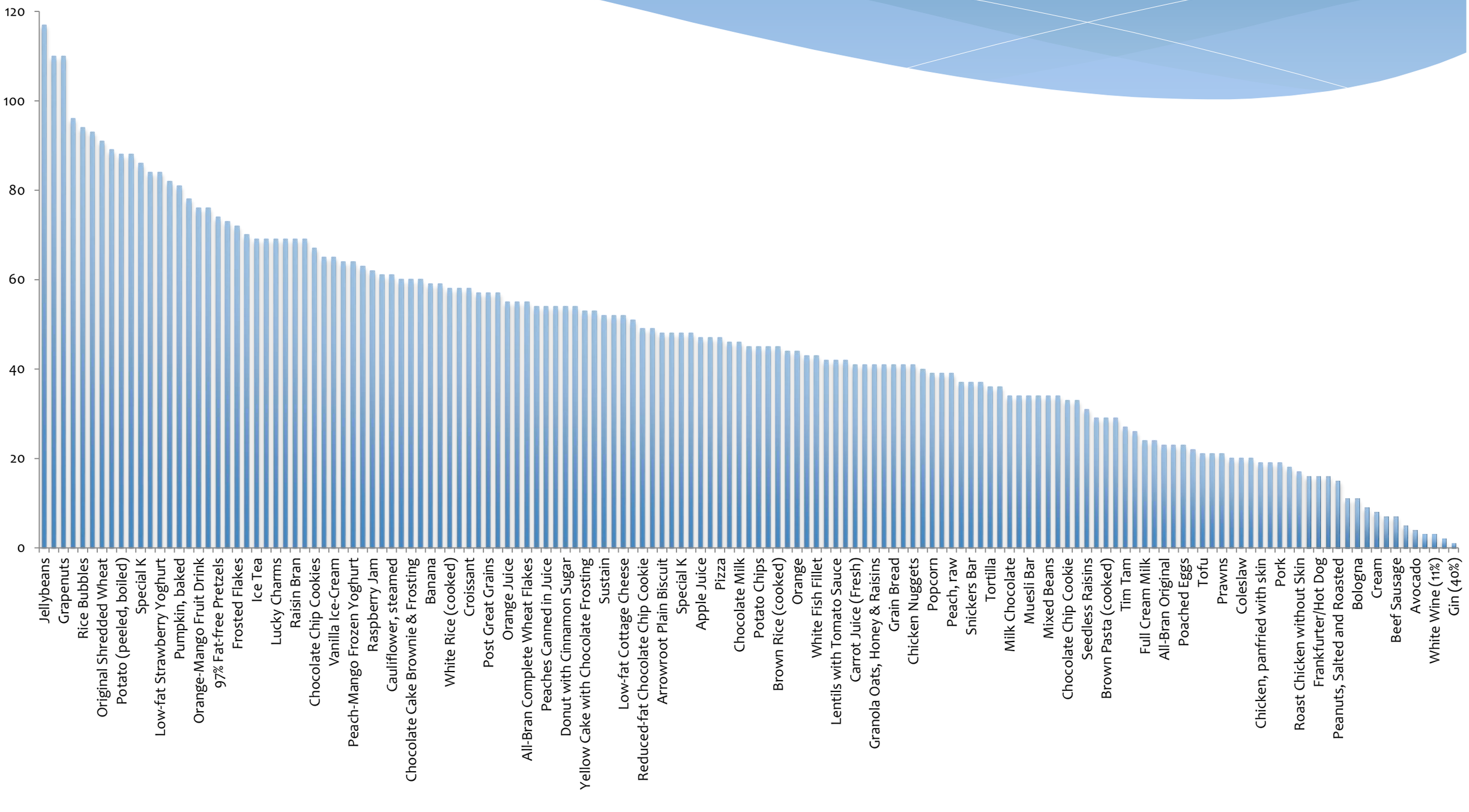
* Foods measured in 1000kJ portions
* Relative to a reference food

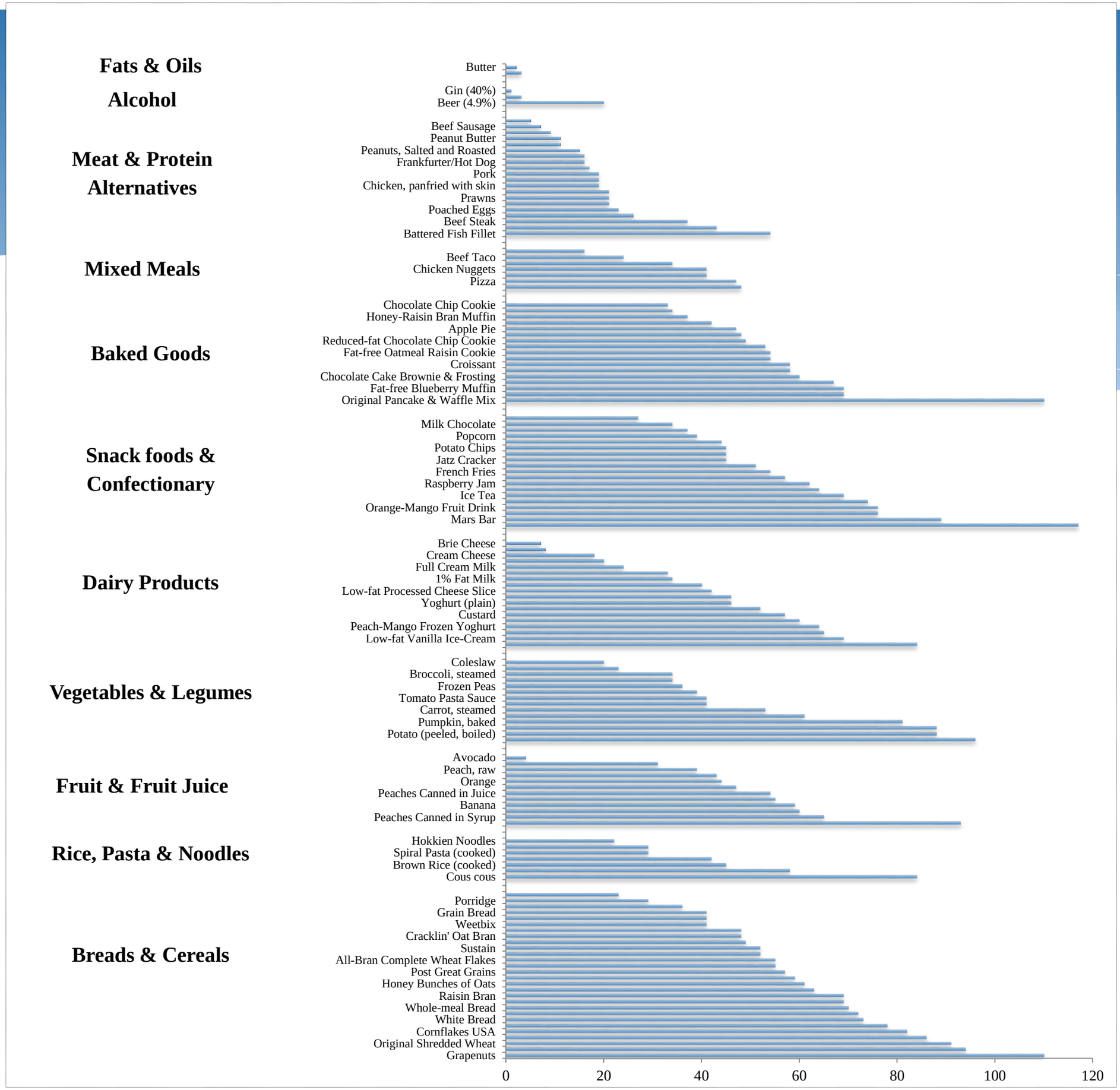
$$FII = \frac{\text{120min AUC}_{\text{Insulin}} \text{ for 1000kJ of test food}}{\text{120min AUC}_{\text{Insulin}} \text{ for 1000kJ of ref. food}} \times 100$$

* Published FII represents the average of 10 subjects
* Developed a FII database of 147 foods

Bao et al. Am J Clin Nutr 2011; 93:984–96

FII Varies Over A Wide Range




Fats & Oils
Alcohol
Meat & Protein Alternatives
Mixed Meals
Baked Goods
Snack foods & Confectionary
Dairy Products
Vegetables & Legumes
Fruit & Fruit Juice
Rice, Pasta & Noodles
Breads & Cereals
Butter
Gin (40%)
Beer (4.9%)
Beef Sausage
Peanut Butter
Peanuts, Salted and Roasted
Frankfurter/Hot Dog
Pork
Chicken, panfried with skin
Prawns
Poached Eggs
Beef Steak
Battered Fish Fillet
Beef Taco
Chicken Nuggets
Pizza
Chocolate Chip Cookie
Honey-Raisin Bran Muffin
Apple Pie
Reduced-fat Chocolate Chip Cookie
Fat-free Oatmeal Raisin Cookie
Croissant
Chocolate Cake Brownie & Frosting
Fat-free Blueberry Muffin
Original Pancake & Waffle Mix
Milk Chocolate
Popcorn
Potato Chips
Jatz Cracker
French Fries
Raspberry Jam
Ice Tea
Orange-Mango Fruit Drink
Mars Bar
Brie Cheese
Cream Cheese
Full Cream Milk
1% Fat Milk
Low-fat Processed Cheese Slice
Yoghurt (plain)
Custard
Peach-Mango Frozen Yoghurt
Low-fat Vanilla Ice-Cream
Coleslaw
Broccoli, steamed
Frozen Peas
Tomato Pasta Sauce
Carrot, steamed
Pumpkin, baked
Potato (peeled, boiled)
Avocado
Peach, raw
Orange
Peaches Canned in Juice
Banana
Peaches Canned in Syrup
Hokkien Noodles
Spiral Pasta (cooked)
Brown Rice (cooked)
Cous cous
Porridge
Grain Bread
Weetbix
Cracklin' Oat Bran
Sustain
All-Bran Complete Wheat Flakes
Post Great Grains
Honey Bunches of Oats
Raisin Bran
Whole-meal Bread
White Bread
Cornflakes USA
Original Shredded Wheat
Grapenuts
0
20
40
60
80
100
120
Food Insulin Index (%)

Food Examples

1000kJ (240kcal) Portions

Grain Bread

Carbohydrate: 40g

FII: 41

White Bread

Carbohydrate: 44g

FII: 73

Boiled Potato

Carbohydrate: 49g

FII: 88

Low Fat Yoghurt

Carbohydrate: 38g

FII: 84

Apple

Carbohydrate: 58g

FII: 43

Mars Bar

Carbohydrate: 38g

FII: 89

Food Examples

1000kJ (240kcal) Portions

Beef Steak
Carbohydrate: 0g
FII: 37

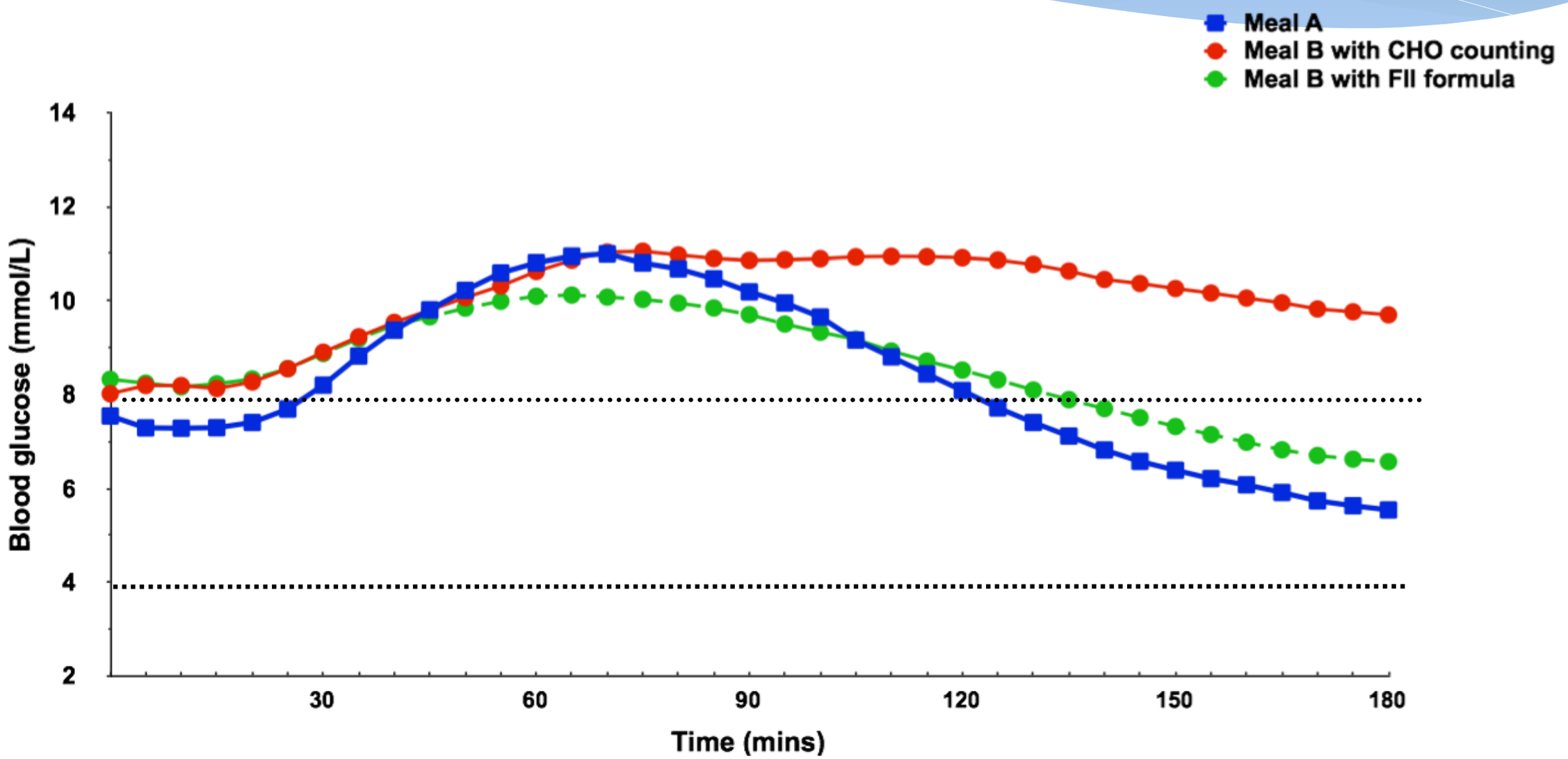
Poached Eggs
Carbohydrate: 1g
FII: 23

Chicken
Carbohydrate: 0g
FII: 19

Bao et al. Am J Clin Nutr 2011; 93: 984–96

Can the Food Insulin Index be used to Predict Mealtime Insulin Requirements in Type 1 Diabetes?

FII Improves Postprandial Glycaemic Control



Bao et al. Diabetes Care 2011; 34(4):2146-2151

Conclusion

FII improved acute postprandial glycaemia compared to carbohydrate counting without increasing the risk of hypo's

But this study only looked at mixed meals, what about single protein foods?

How Would We Use The FII in Practice?

(Type 1 Diabetes)

FII vs FID

Food Insulin Index (FII) is a measure of a food's relative insulin demand compared with other foods

* I.e. The FII is a fixed value that doesn't change as the food portion size changes.

Apple
FII: 43

Food Insulin Demand (FID) combines a food's FII with the kJ in the portion size

- I.e. The FID changes as the food portion size changes and can therefore be used to determine the mealtime insulin dose.

White Bread, 1 Slice
FII: 73
FID: 26

Food Insulin Demand

$$FID = \frac{\text{Energy (kJ)} \times \text{Food Insulin Index (FII)}}{1{,}000}$$

e.g. 200g low-fat strawberry yoghurt (FII = 84)

$$FID = \frac{770\text{kJ} \times 84}{1{,}000}$$

FID = 65

Using FID in Practice

* Jane eats 200g of her low-fat strawberry yoghurt
* Insulin Demand (FID) = 65

* Jane's 'Insulin: FID' ratio is 1:16
* Therefore, Jane needs 4 units of insulin to cov
her yoghurt

Pictorial Resources

FOOD INSULIN DEMAND (FID) COUNTING

FOOD REFERENCE GUIDE FOR PEOPLE WITH TYPE 1 DIABETES

THE UNIVERSITY OF SYDNEY

Breads

White Bread
1 Slice (35g)
FID: 26

Grain Bread
1 Slice (28g)
FID: 11

Wholemeal Bread
1 Slice (40g)
FID: 28

Soy & Linseed Bread
1 Slice (41g)
FID: 22

Tortilla
1 Tortilla (40g)
FID: 14

Croissant
1 Medium (50g)
FID: 44

Meats & Chicken

Beef Steak
150g Raw, 130g Cooked
FID: 30

Panfried Chicken
150g Raw, 130g Cooked
FID: 26

Roast Chicken
130g Cooked
FID: 20

Short-Cut Bacon
2 Rashers (72g)
FID: 6

Frankfurter (Hot Dog)
1 Thin
FID: 12

Fruit

Apple
1 Medium (150g)
FID: 14

Orange
1 Medium (230g)
FID: 11

Banana
1 Medium (170g)
FID: 23

Honeydew Melon
1 Slice (100g)
FID: 7

Sultanas
40g (1/4 Cup)
FID: 17

Grapes
12 Grapes (120g)
FID: 18

Dairy Products

Skim Milk
250mL (1 Cup)
FID: 23

Full Cream Milk
250mL (1 Cup)
FID: 17

Low Fat Fruit Yoghurt
175g Tub
FID: 57

Vanilla Ice-Cream
1 Scoop (50g)
FID: 27

Low Fat Vanilla Ice-Cream
1 Scoop (50g)
FID: 19

Fruit Frozen Yoghurt
1 Scoop (50g)
FID: 18

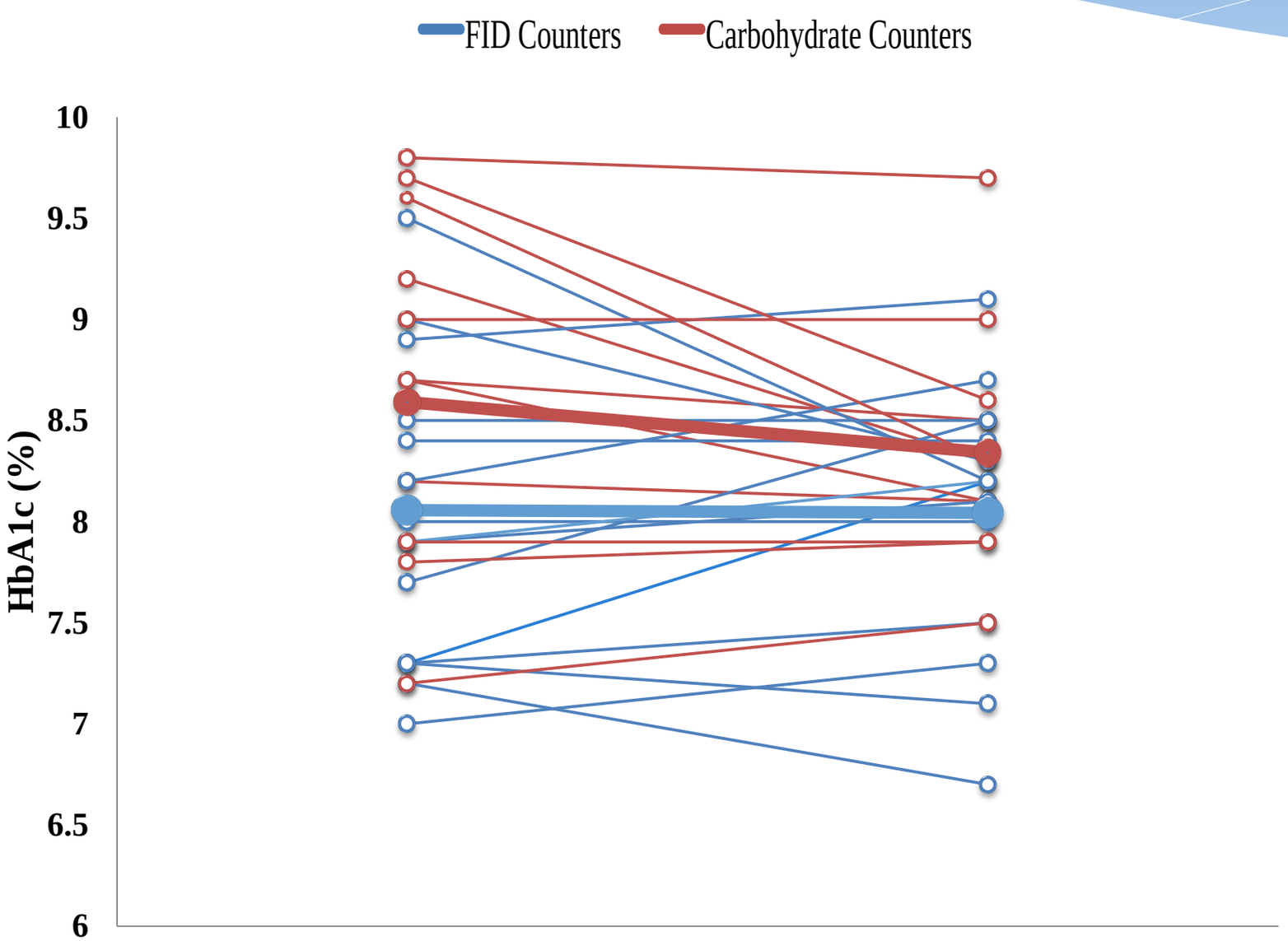
Does the FII work in Practice?

The FOODII Study

* 26 Adults with type 1 diabetes, using insulin pumps
* 3 months, parallel, randomised controlled trial
* Carbohydrate counting vs FID Counting
* Receive dietary education at baseline (1 x group workshop and 1 x individual appt.)
* HbA1c and Continuous Glucose Monitoring (CGM) for 6 days at baseline and at 3 months

Bell et al. Diabetes 2014; 43 (S1): A189

FII as Effective As Carb Counting for Glycaemic Control



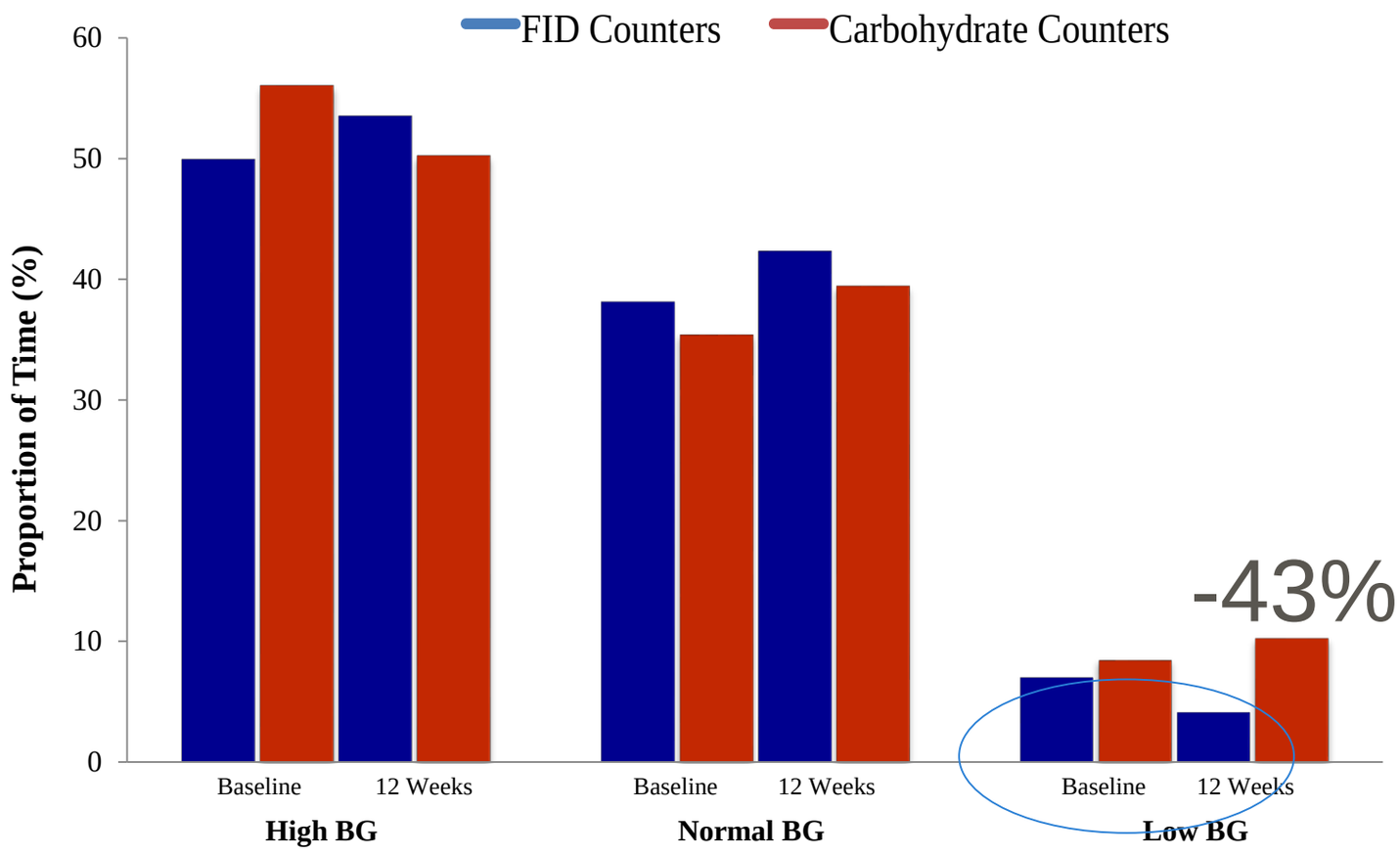
Carb: -0.3%

FII: -0.1%

p = 0.855

Bell et al. Diabetes 2014; 43 (S1): A189

FII May Lower Risk of Hypo



	Baseline	12 Weeks	P Value
FID Counting	7.1%	4.0%	0.058
Carbohydrate Counting	8.5%	9.4%	0.682

Bell et al. Diabetes 2014; 43 (S1): A189

Participant Feedback

* All agreed the method was easy to use
* All agreed they were able to enjoy a wide range of foods
* About half of both groups felt their blood glucose levels were better managed during the study
    * None felt their glycaemic control had deteriorated
* 46% of FID Counters would continue using the FII if able to

Bell et al. Diabetes 2014; 43 (S1): A189

Conclusion

Changes in HbA1c and postprandial glycaemia were similar using FII counting or carbohydrate counting in a 12-week pilot study.

The near-significant trend to reduced risk of hypoglycaemia in FII counters warrants further study.

Summary

* Fat, protein and carbohydrate all influence postprandial glycaemia in T1D – consider adjusting insulin for advanced patients
* The Food Insulin Index ranks foods based on their insulin demand in healthy subjects relative to an isoenergetic reference food (fixed value)
* May be a useful tool for estimating mealtime insulin doses
* Research continuing - watch this space!
* Currently carbohydrate counting is the gold standard