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

Glycaemic Response

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
  - Insulin
  - Meal

- Elevated BGL
  - Increased hepatic glucose output
  - Insulin resistance
  - Meal
Fat and Protein Increase Insulin Requirements

Smart et al. Diabetes Care 2013; 36: 3897-3902
Pure Protein Increases BG
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
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
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
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.

Adjusting Insulin for Protein & Fat
Can We Do Better?
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

Estimating Mealtime Insulin Dose in Type 1 Diabetes

Current Thinking

Carbohydrate Counting

Glycaemic Response

Bolus Insulin Dose

Novel Thinking

Insulin Response in Healthy Individuals

Insulin Demand

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

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

Calculating the AUC

![Graph showing Insulin Concentration over Time with AUC comparisons: FII: 100 and FII: 60]
Food Insulin Index (FII)

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\]

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

FII Varies Over A Wide Range
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

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)
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.

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.
Food Insulin Demand

FID = Energy (kJ) x Food Insulin Index (FII) \[\frac{1,000}{1,000}\]

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

\[
FID = \frac{770kJ \times 84}{1,000}
\]

\[\frac{1,000}{1,000}\]

FID = 65
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 cover her yoghurt
Pictorial Resources

FOOD INSULIN DEMAND (FID) COUNTING
FOOD REFERENCE GUIDE FOR PEOPLE WITH TYPE 1 DIABETES

Breads
- White Bread 1 slice (25g) FID: 24
- Grais Bread 1 slice (25g) FID: 14
- Wholemeal Bread 1 slice (25g) FID: 16
- Sog & Unseeded Bread 1 slice (25g) FID: 22
- Tortilla 1 tortilla (85g) FID: 18
- Croissant 1 Croissant (25g) FID: 14

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 (110g) FID: 14
- Orange 1 Medium (110g) FID: 17
- Kiwifruit 1 Kiwi (80g) FID: 12

Dairy Products
- Slices Milk 200ml (6.7g) FID: 10
- Full Cream Milk 200ml (14g) FID: 17
- Low Fat Yoghurt 150ml (7g) FID: 57
- Vanilla Ice-Cream 1 Scoop (95g) FID: 37
- Low Fat Vanilla Ice-Cream 1 Scoop (95g) FID: 19
- Fruit Freeze Yoghurt 1 Scoop (95g) 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
FID May Lower Risk of Hypo

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>12 Weeks</th>
<th>P Value</th>
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<tbody>
<tr>
<td>FID Counting</td>
<td>7.1%</td>
<td>4.0%</td>
<td>0.058</td>
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<tr>
<td>Carbohydrate Counting</td>
<td>8.5%</td>
<td>9.4%</td>
<td>0.682</td>
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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
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.
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