



## Insulin Dosing for Fat and Protein in Type 1 Diabetes

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### Disclosure

No relevant Conflict of Interest

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### Carbohydrate to Insulin Ratio, circa 1935

10. How Many Grams of Carbohydrate Will One Unit Metabolize? This question has one true answer. There are always adjustments required for exercise and diet.

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### The Current Approach: Food Insulin Dose Calculation

$$\boxed{\text{Carbohydrate quantity}} \times \boxed{\text{Insulin-to-Carb ratio}} = \boxed{\text{Insulin dose}}$$

This dosing formula - which is incorporated in current insulin bolus calculators - has never been scientifically validated

Does this approach work in practice?

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### The Current Approach: Assumptions and Limitations... Food Insulin Dose Calculation

$$\boxed{\text{Carbohydrate quantity}} \times \boxed{\text{Insulin-to-Carb ratio}} = \boxed{\text{Insulin dose}}$$

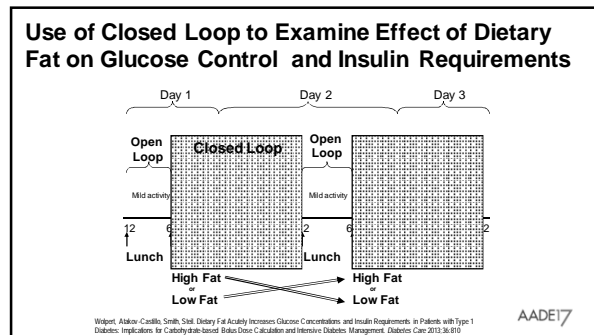
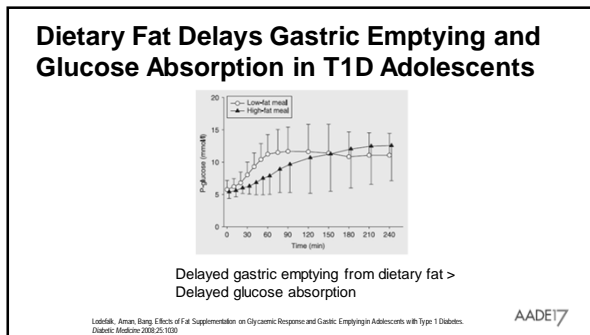
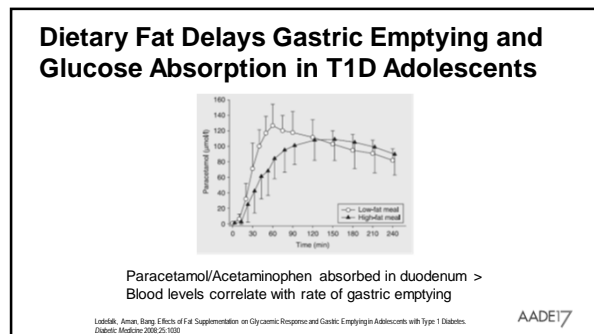
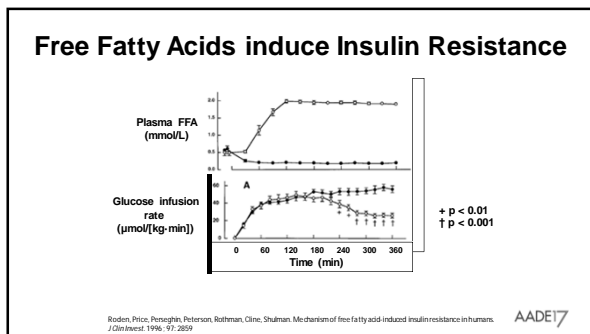
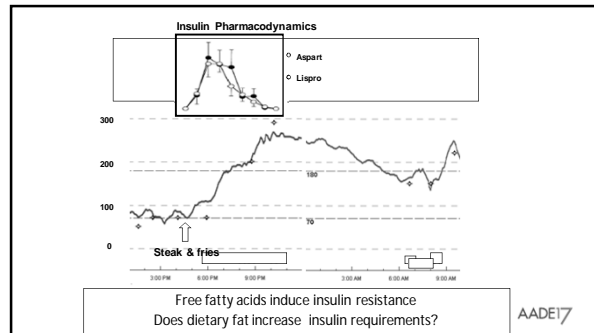
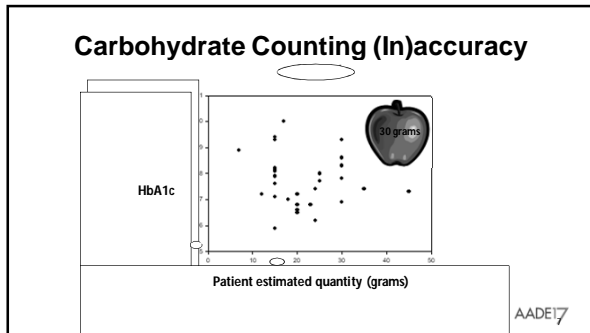
Assumes that accuracy in carb counting is a feasible goal for most patients

Is this a realistic goal?

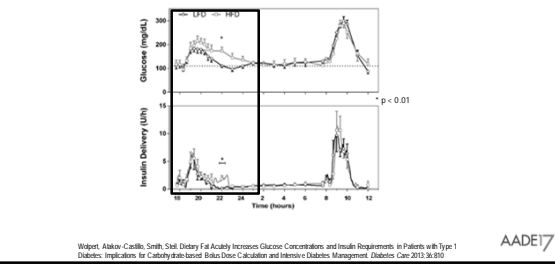
Assumes that carbs are the only dietary ingredient that affects insulin requirements

Is there any scientific validity to carb-based insulin dosing?

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### Use of Closed Loop to Examine Effect of Dietary Fat on Glucose Control and Insulin Requirements



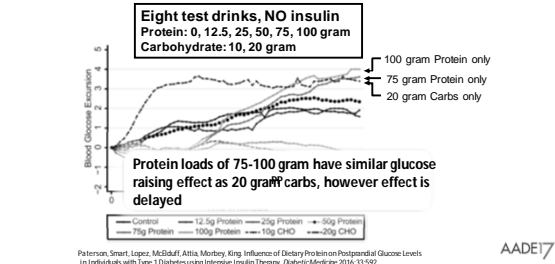
### Marked Inter-individual Differences in Fat Sensitivity

**Carbohydrate-to-Insulin Ratio for Low Fat Dinner (LFD) vs High Fat Dinner (HFD): Carbohydrates consumed 6pm -11pm/total insulin delivered**

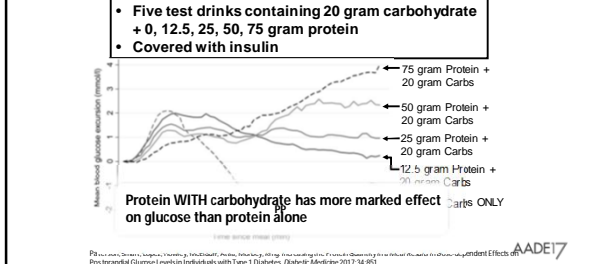
Subject	LFD	HFD	% increase for HFD
#1	14.9	10.4	43%
#2	9.6	7.2	34%
#3	17.8	11	62%
#4	13.2	10.3	28%
#5	9.9	4.8	108%
#6	9.3	11.2	---
#7	12.8	9.4	36%

Wolpert, Abkov-Casillo, Smith, Skell. Dietary Fat Acutely Increases Glucose Concentrations and Insulin Requirements in Patients with Type 1 Diabetes: Implications for Carbohydrate-based Bolus Dose Calculation and Intensive Diabetes Management. Diabetes Care 2013;36:810

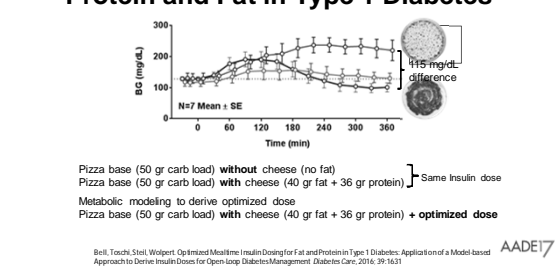
### Effect of Protein only - WITHOUT Carbohydrate and Fat - on Glucose Concentrations



### Effect of Protein WITH Carbohydrate on Glucose Concentrations



### Optimized Mealtime Insulin Dosing for Protein and Fat in Type 1 Diabetes



### Optimized Mealtime Insulin Dosing for

**Optimized Dose for High Fat/High Protein meal:**

DOSE: +65 ± 10% (Range: 17 – 124%)

DURATION: 2.4 ± 0.1 hr (Range: 2 – 3hr)

SPLIT: 30/70% (Range: 10/90% to 50/50%)

**Marked inter-individual variability**

Pizza base (50 gr carb load) without cheese (no fat)  
Pizza base (50 gr carb load) with cheese (40 gr fat + 36 gr protein) } Same insulin dose

Metabolic modeling to derive optimized dose  
Pizza base (50 gr carb load) with cheese (40 gr fat + 36 gr protein) + optimized dose

Bell, Touch, Sliet, Wolpert. Optimized Mealtime Insulin Dosing for Fat and Protein in Type 1 Diabetes: Application of a Model based Approach to Derive Insulin Doses for Open-loop Diabetes Management. Diabetes Care 2016; 39:1631

**Where to Start with Dosing Recommendations for Higher Fat Meals:**

1. Calculate insulin dose based on CIR & Carb content of meal, then add +30%
2. Deliver over 2-3 hours
3. Distribution of bolus, dependent on Carb type  
If Pizza or Pasta (GI 50 or less): start with 30% initially
4. Consider dose reduction if exercise preceding higher fat meal, or alcohol with meal
5. RE-EVALUATE, RE-EVALUATE, RE-EVALUATE

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**Unanswered Questions:**

- What are the predictors of inter-individual differences in fat sensitivity?
- Is there a fat threshold or dose-response effect?
- Does fat type matter?
- Does carb quantity and/or type matter?

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**CONCLUSION:  
Need to Shift from Carb-based to Meal-centric Paradigm for Insulin Bolusing**

**BUT...**

"Carbohydrate counting is a challenging aspect to diabetes self-management, and requiring that fat and protein intake also be quantitated and incorporated in insulin dosing decisions will create an additional burden that few patients will be able to accomplish."

Bell, Smart, Steil, Brand-Miller, King, Waljeet. Impact of Fat, Protein and Glycemic Index on Postprandial Glucose Control in Type 1 Diabetes: Implications for Intensive Diabetes Management in the Continuous Glucose Monitoring Era. Diabetes Care 2015; 38:1008 AADE17

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