

# Carb Counting and CGM

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Carbohydrate counting and CGM

**OPTIMAL POSTPRANDIAL CONTROL IS  
CLASSIFIED AS ONE OF THE MOST  
CHALLENGING ASPECTS OF TYPE 1  
DIABETES MANAGEMENT**



# Carbohydrate Counting

- Carbohydrate counting is a **tool** that helps patients to **estimate in a systematic way the amount of the pre-meal insulin bolus** to minimize the glucose increase after a meal, and if necessary, to **correct an either inappropriately high or low pre-meal glucose level**.



# Why Carb Count?

- Primary goal of diabetes management is to normalize blood glucose concentrations
- Both MDI and CSII require patient (or parent) input of CHO to determine proper insulin bolus doses



# I:CHO Ratio

- Daily insulin requirement is associated with the amount rather than the type of daily carbohydrate intake
- **Insulin:CHO ratio is the most advanced counting technique**



# Insulin : CHO Ratio

- **I:CHO Ratio:**
  - estimation of the mean insulin-to-carbohydrate ratio (i.e., the prandial insulin need)
- **This algorithm does not take into account:**
  - intra-individual glycemic variability due to variations in insulin sensitivity (between-day changes)
  - estimation and/or absorption of carbohydrates (CHOs)
  - insulin absorption



# Carb Counting - Advances

- Reduction in HbA1c
- No indications of an association between weight change and advanced carbohydrate counting
- No increased risk of hypoglycemia (patients with hypoglycemia unawareness? - unclear)

Schmidt, S., Schelde, B. & Nørgaard, K. Effects of advanced carbohydrate counting in patients with Type 1 diabetes: a systematic review. Diabet. Med. 31, 886–896 (2014).



# Factors responsible for intervention failure or success are difficult to identify

- Patients ability to accurately assess the carbohydrate contents of meals
- Overall understanding of the diabetes disease and the dynamics of glucose homeostasis
- Patient adherence to CHO counting
- Competences of the healthcare team in providing training in advanced CHO counting





# Barriers to glycemic control

- Underestimation of meals (more common with larger meals)
- Fear of hypoglycemia
- Anticipated Exercise
- CHO counting ability



# Accuracy of CHO counting

- Patients mean error of CHO estimates per meal is about 20%
- Underestimation of CHO is common (about 60% of the meals' CHO are underestimated)
- Inaccurate CHO counting is frequent and associated with higher daily blood glucose variability in adults with T1DM



# Carb Counting ... Not always easy



# Carbohydrates

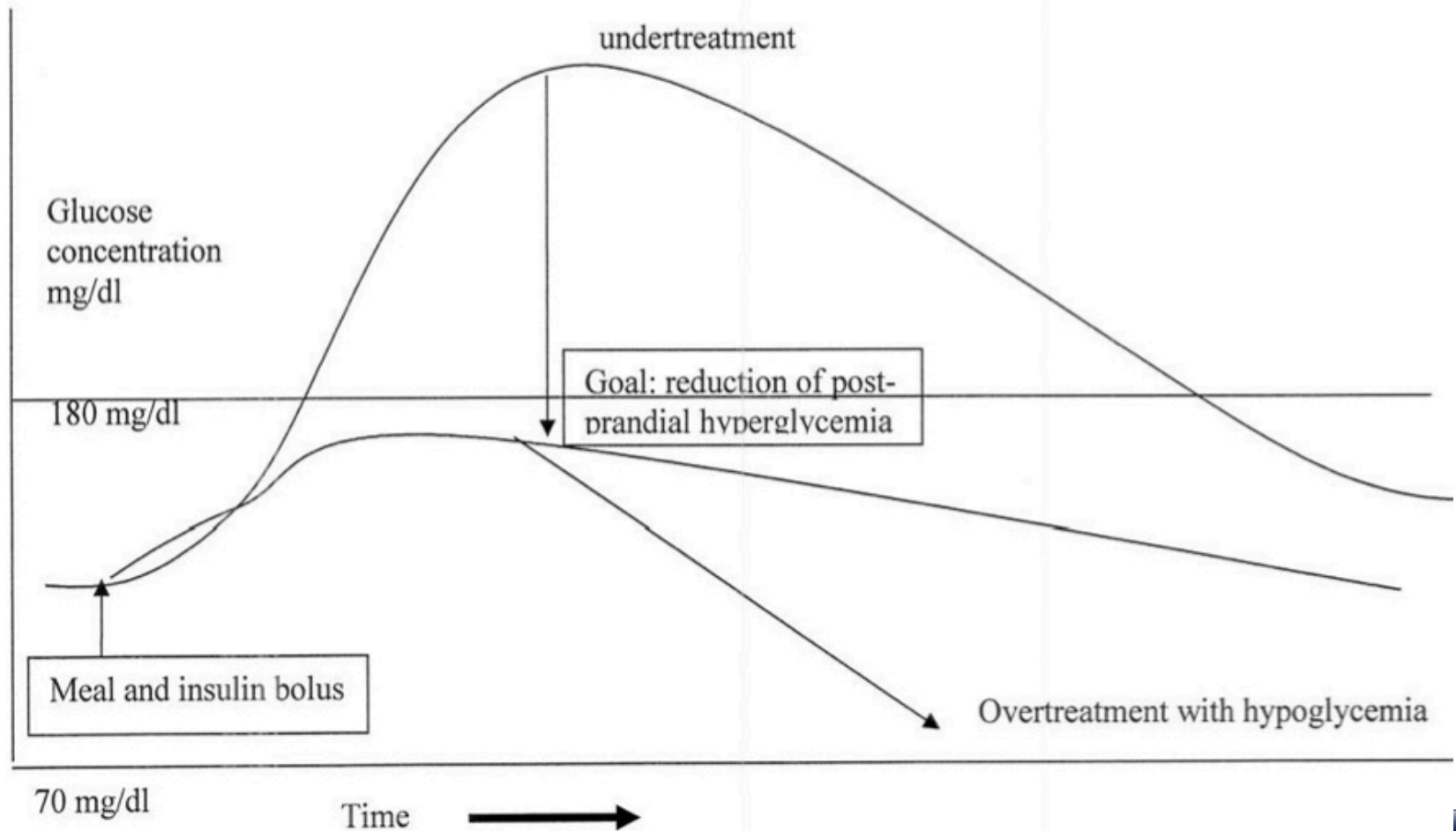
Easy ?



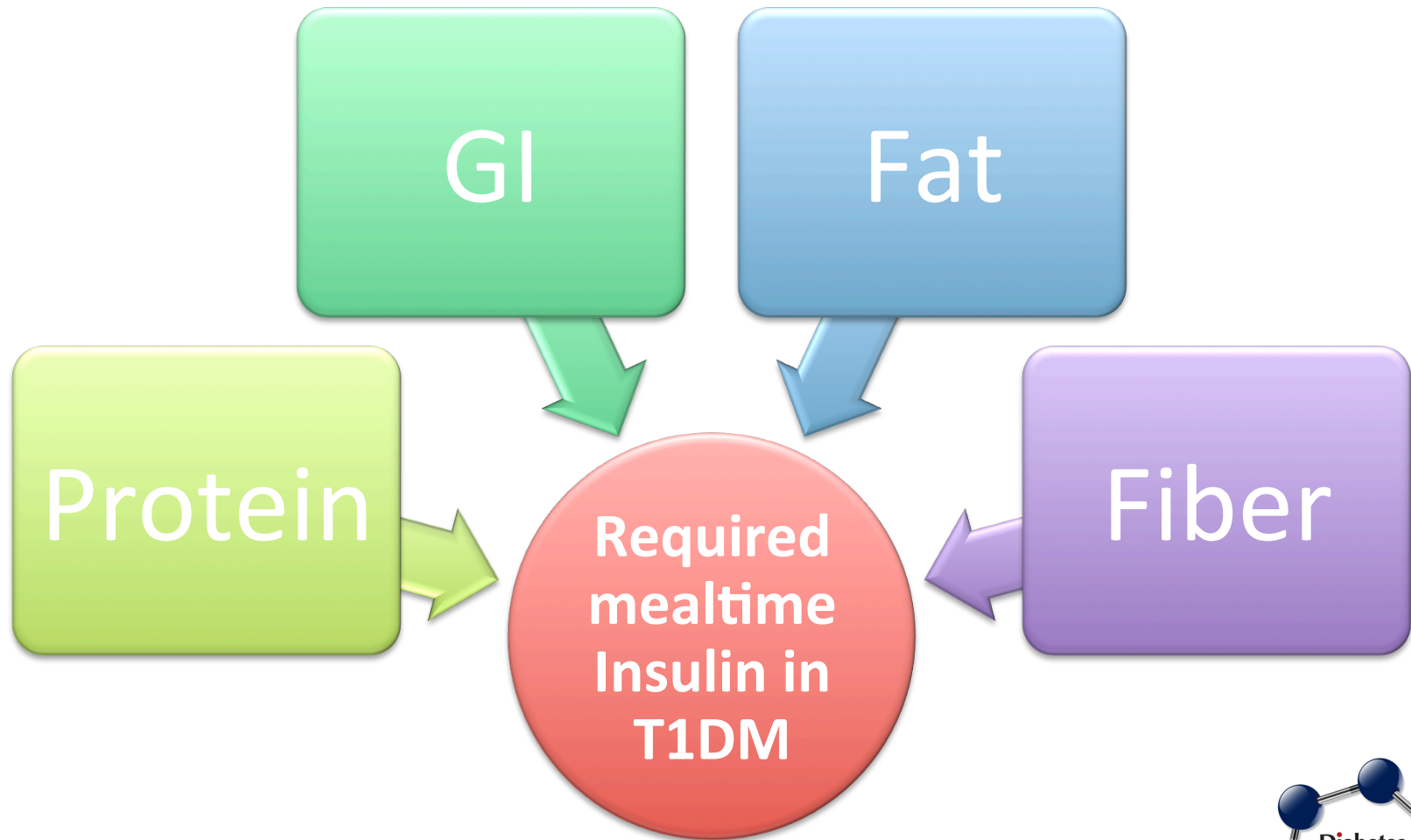
Difficult ?



# Glycemic excursion, Insulin, CHOs



# Carbohydrate Counting



# Problem

Carbohydrate counting is the standard in determining/calculating pre meal insulin



Reports of elevated postprandial glucose levels and high levels for 2 or 3 h, particularly after the ingestion of meals with high protein and/or fat content



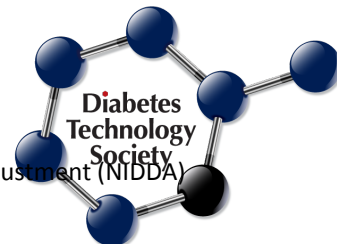
Elevated postprandial glucose increases the risk of cardiovascular disease, atherosclerosis, and mortality





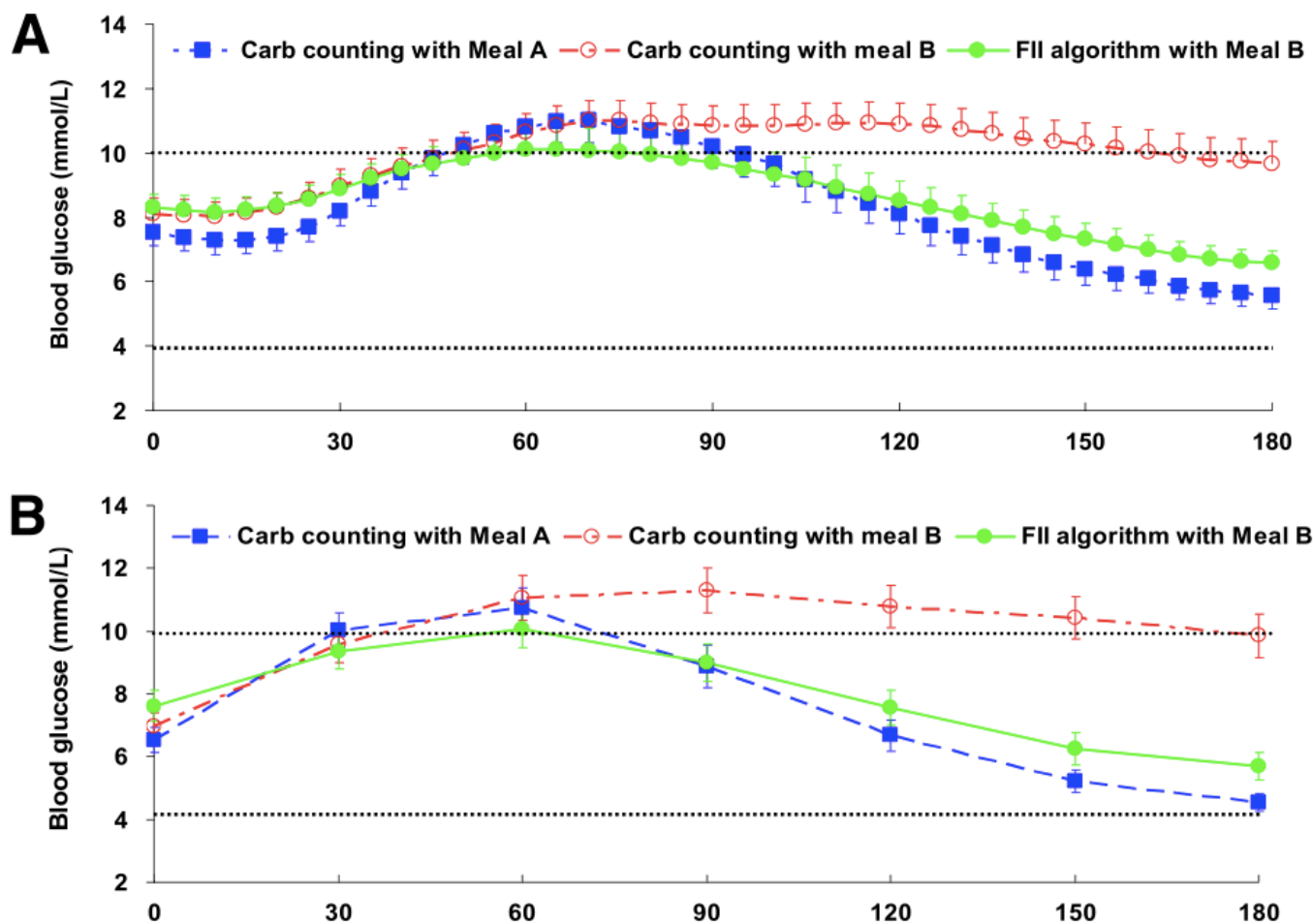
# Two meals

- Meal A:
  - Meal A was designed to contain 75 g carbohydrate with only 20% of energy derived from protein and fat
- MEAL B:
  - approximately half the carbohydrate content of meal A but the same insulin demand based on knowledge of the FII values of the component foods





# FII algorithm vs carb counting



Bao, J. et al. Improving the estimation of mealtime insulin dose in adults with type 1 diabetes: the Normal Insulin Demand for Dose Adjustment (NIDDA) study. Diabetes Care 34, 2146–2151 (2011).



# Diabetes technology

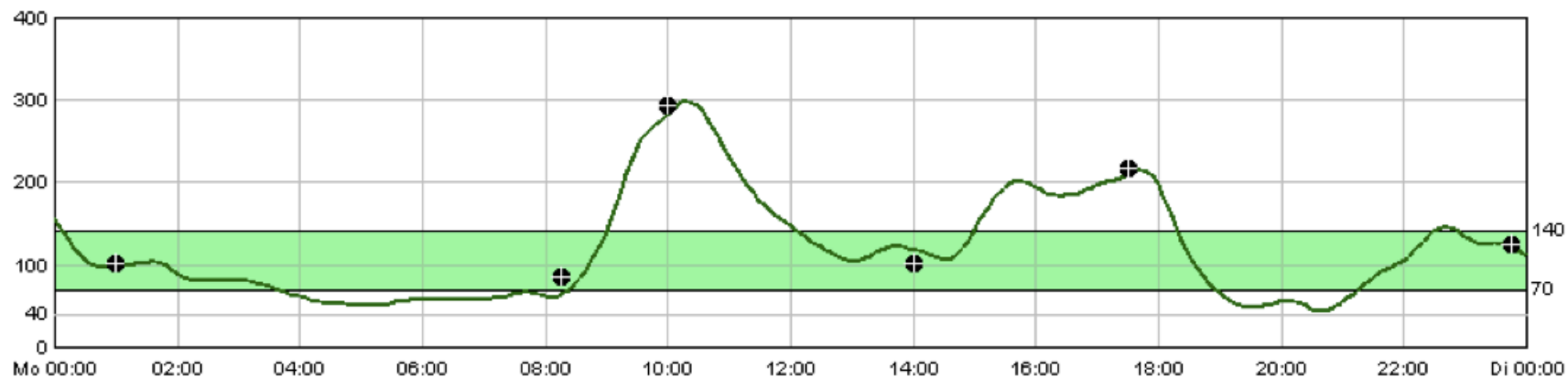
- Technological improvements in insulin pumps and continuous glucose monitors help patients with type 1 diabetes manage the challenge of insulin administration



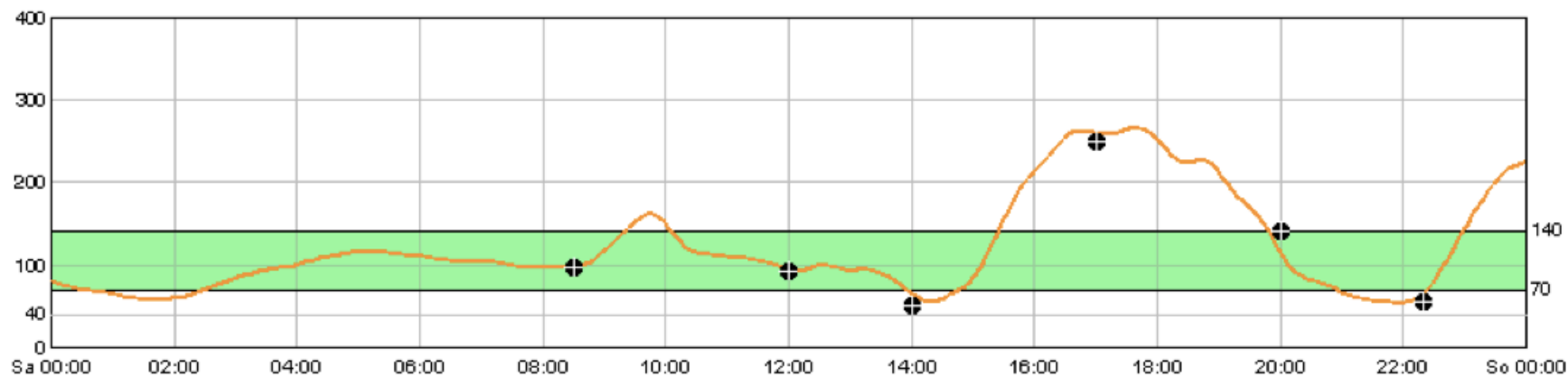
# Recommendations: Glucose Monitoring

- Continuous glucose monitoring (CGM) with intensive insulin regimens useful tool to lower A1C in selected adults (age  $\geq 25$  years) with type 1 diabetes
- Evidence for A1C-lowering less strong in children, teens, and younger adults; however, CGM may be helpful; success correlates with adherence to device use
- CGM may be a supplemental tool to SMBG in those with hypoglycemia unawareness and/or frequent hypoglycemic episodes

# Example 1

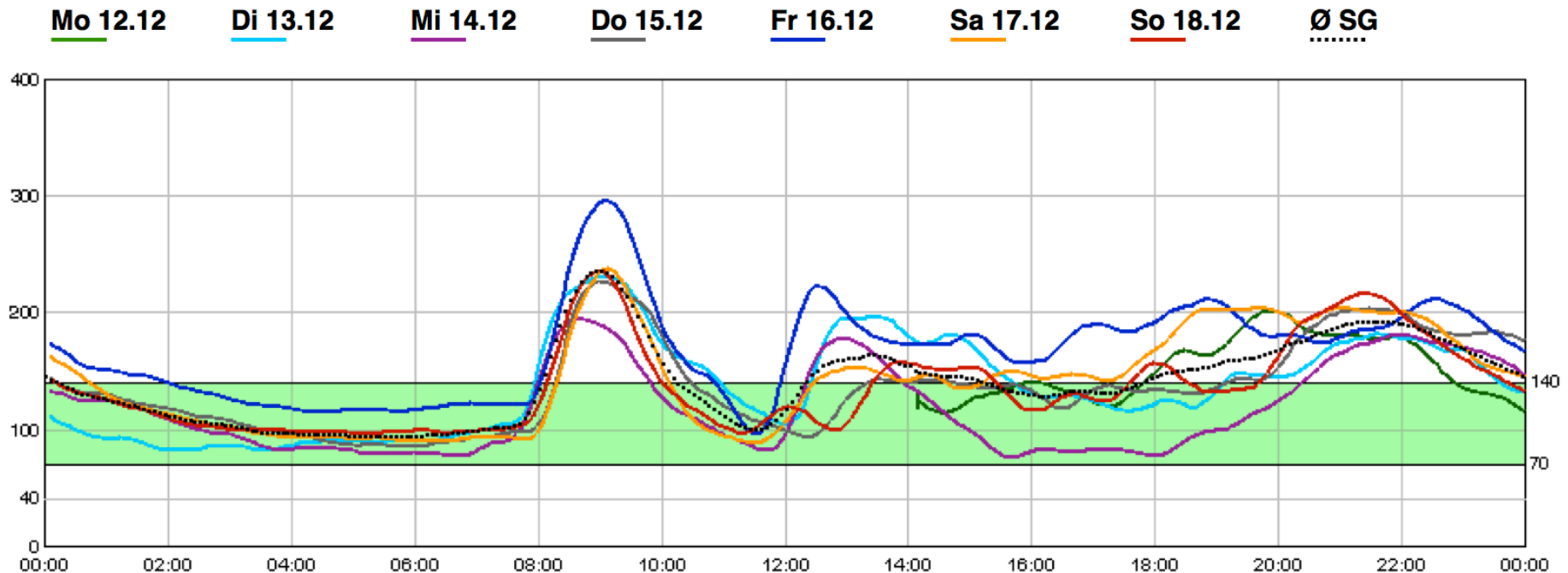


# Example 2



# Example 3

## Sensordaten (mg/dl)



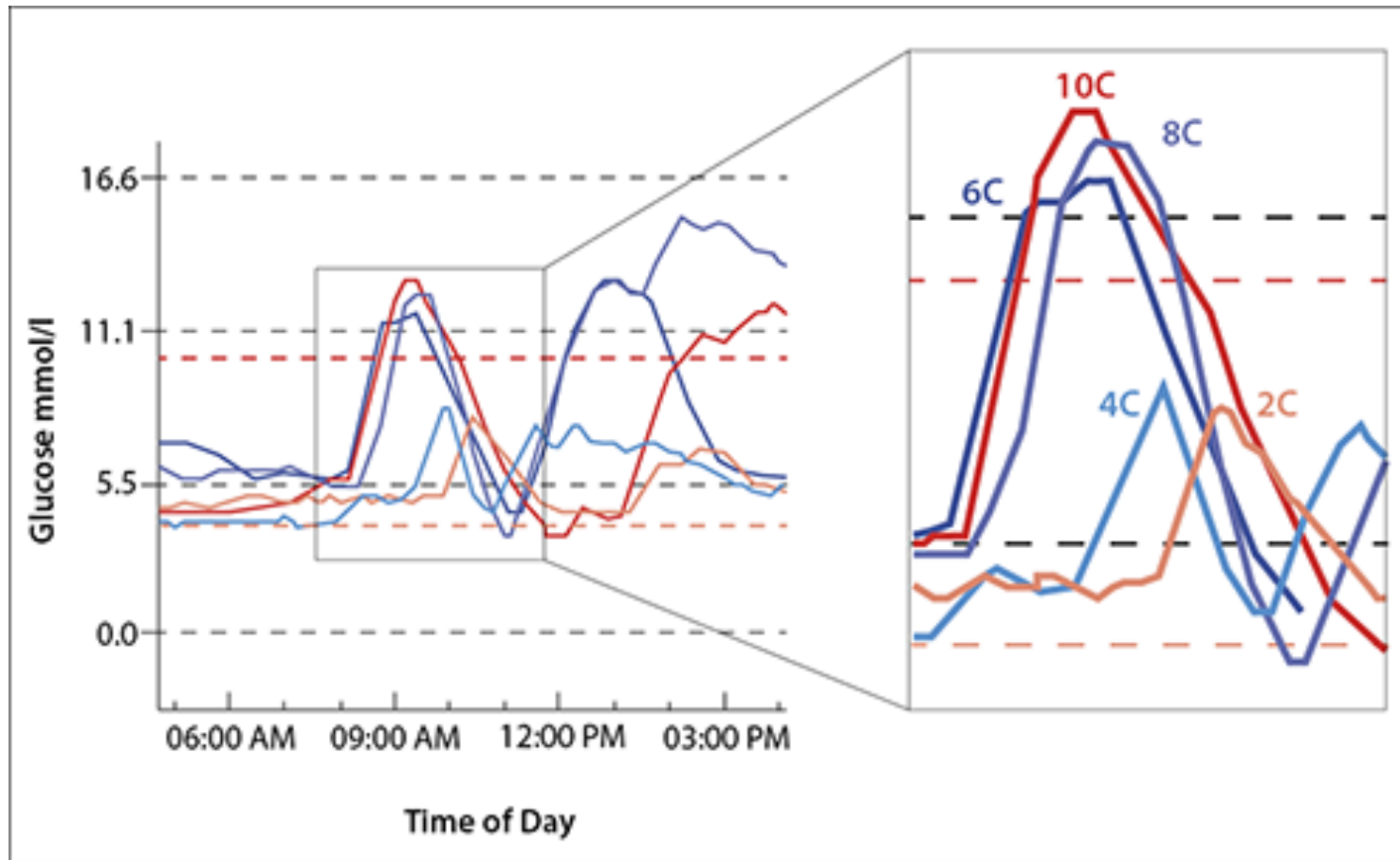
	Mo 12.12	Di 13.12	Mi 14.12	Do 15.12	Fr 16.12	Sa 17.12	So 18.12	Ø / Gesamt
<b>Sensorwerte</b>	119	288	288	288	288	288	288	1.847
<b>Höchste SG</b>	200	231	195	227	295	238	236	295
<b>Niedrigste SG</b>	114	82	77	85	96	89	97	77
<b>Ø SG</b>	152	137	119	137	168	143	136	141
<b>Standardabweich.</b>	26	41	37	37	41	41	36	41
<b>MAD %</b>	8,9	6,3	16,8	4,1	24,5	7,5	12,2	11,4
<b>Korrelation</b>	N/A	0,99	N/A	N/A	0,89	0,94	N/A	0,90
<b>Gültige Kalibrierungen</b>	4	5	4	5	5	5	4	32
<b>Bewertung</b>								

X: Klinische Beurteilung verwenden

S: Keine Sensordaten

C: Keine BZ-Messwerte zur Kalibr.

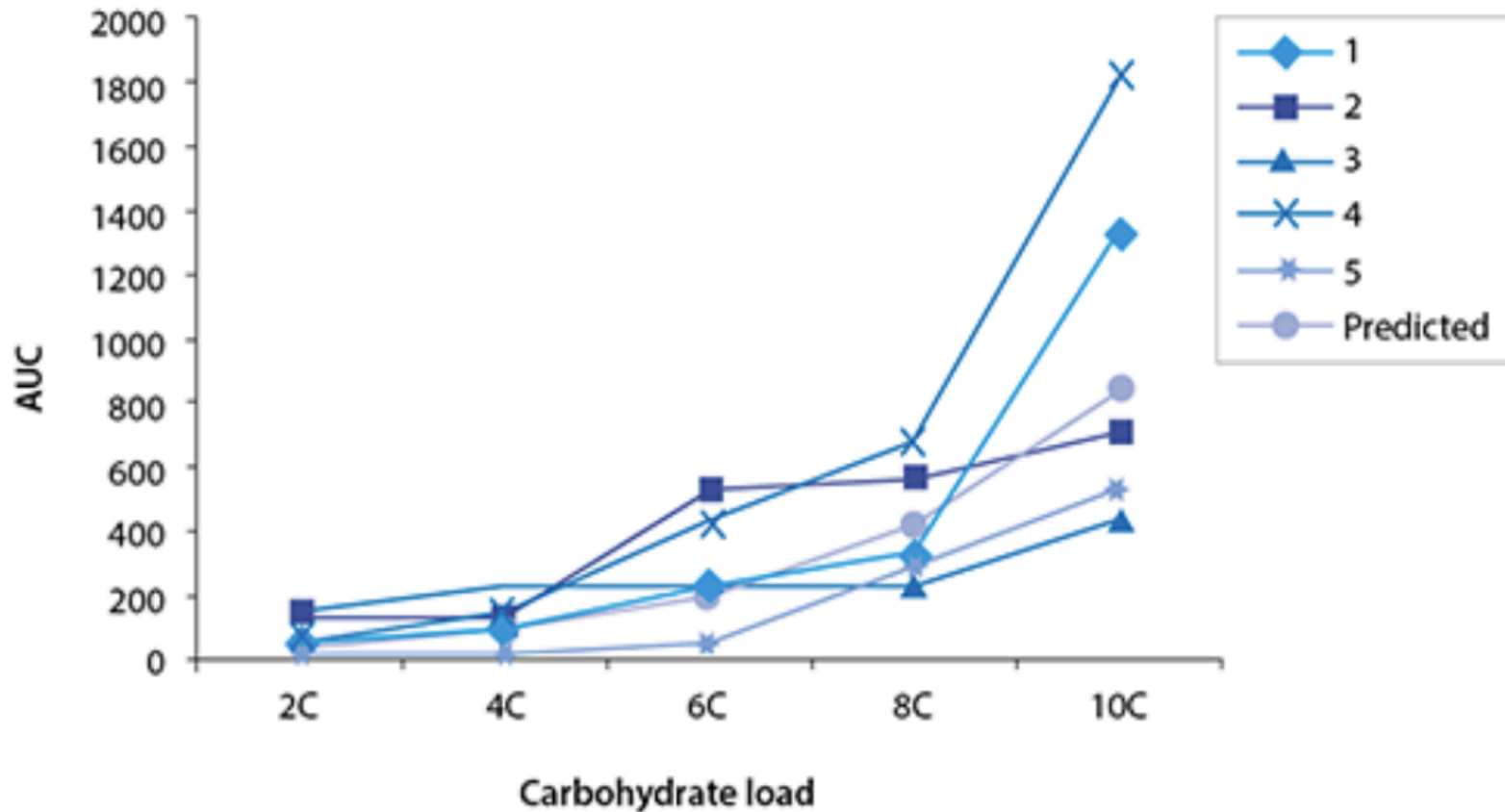
# Increasing carbohydrate loads using a fixed carbohydrate-to-insulin ratio resulted in increasing glucose AUC



Marran, K. J., Davey, B., Lang, A. & Segal, D. G. Exponential increase in postprandial blood-glucose exposure with increasing carbohydrate loads using a linear carbohydrate-to-insulin ratio. *S. Afr. Med. J.* 103, 461–463 (2013).



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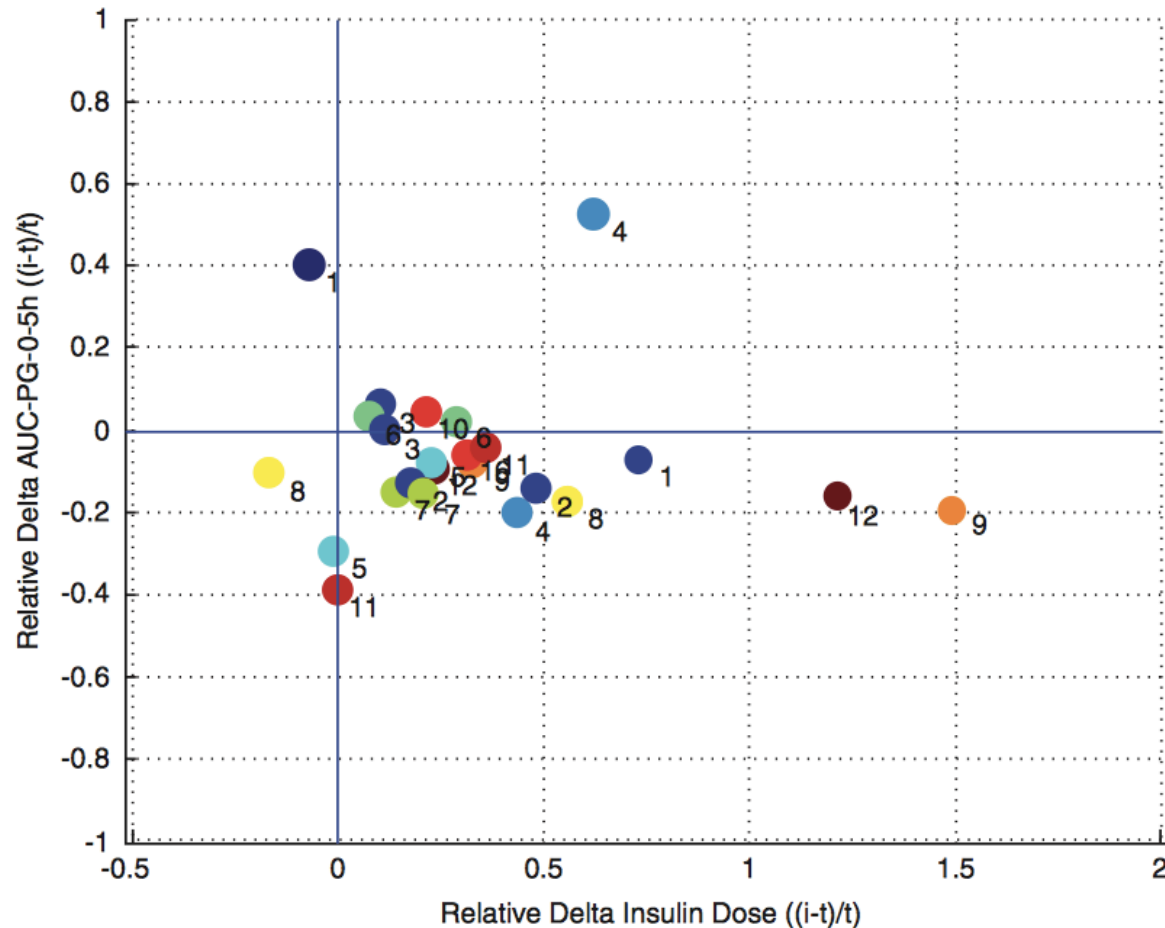


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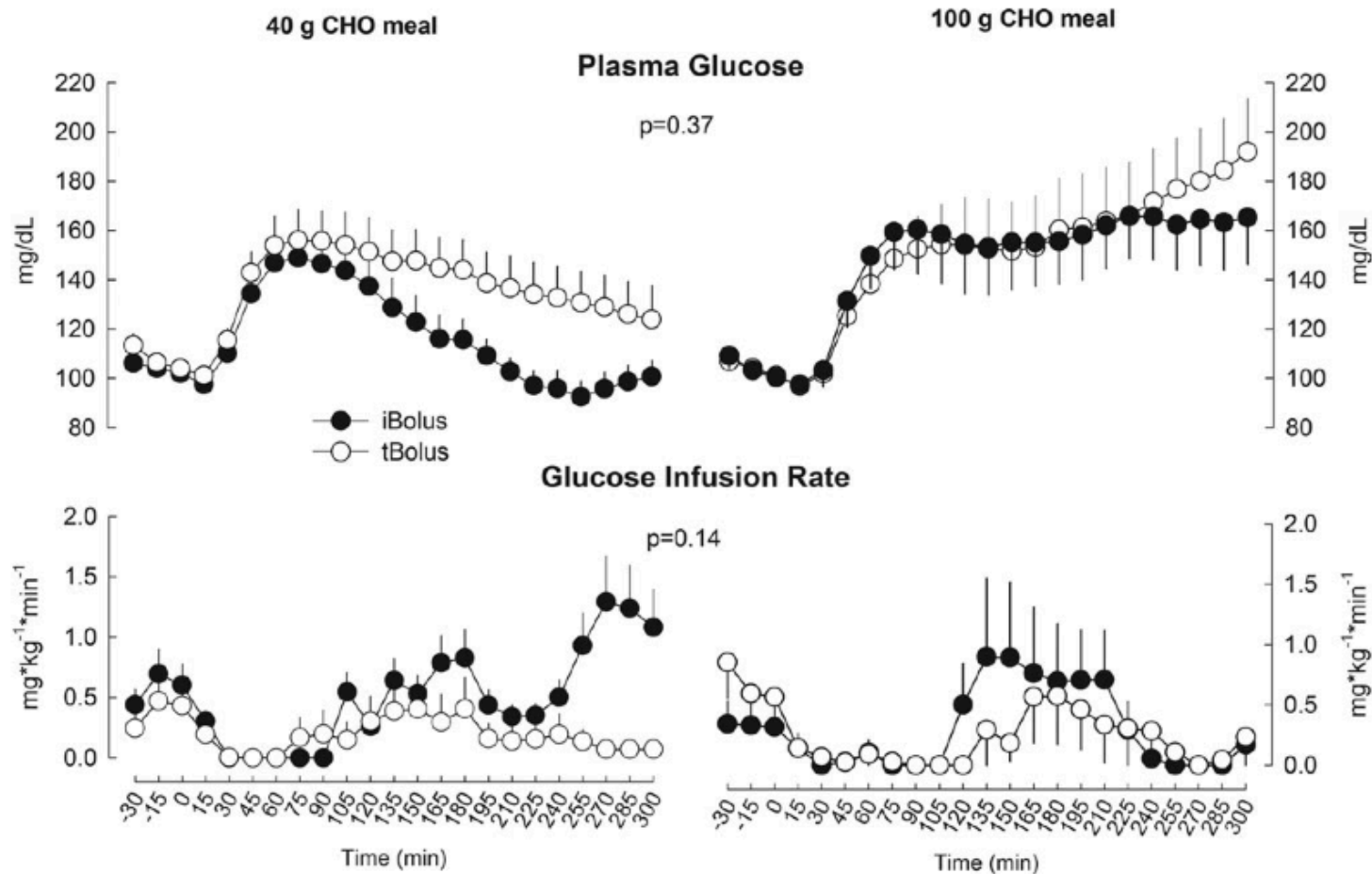




# Intra-individual relative changes in postprandial glucose response to different insulin doses while maintaining the same meal



# Plasma glucose (top) and exogenous glucose infusion rate (bottom) for the iBolus or the tBolus



Rossetti, P. et al. Evaluation of a Novel Continuous Glucose Monitoring-Based Method for Mealtime Insulin Dosing—the iBolus—in Subjects with Type 1 Diabetes Using Continuous Subcutaneous Insulin Infusion Therapy: A Randomized Controlled Trial. *Diabetes Technol. Ther.* 14, 1043–1052 (2012).



# Time Lag of Glucose From Intravascular to Interstitial Compartment in Humans

Ananda Basu,<sup>1</sup> Simmi Dube,<sup>1</sup> Michael Slama,<sup>1</sup> Isabel Errazuriz,<sup>1</sup> Jose Carlos Amezcua,<sup>1</sup> Yogish C. Kudva,<sup>1</sup> Thomas Peyser,<sup>2</sup> Rickey E. Carter,<sup>3</sup> Claudio Cobelli,<sup>4</sup> and Rita Basu<sup>1</sup>

- The physiological delay of glucose transport from the vascular to the interstitial space is 5–6 min
- The physiological time lag of glucose transport between the vascular and ISF compartments is considerably shorter than many have hypothesized



# Conclusion

- **CHO counting:**
  - Matching insulin to the carbohydrate amount of a meal is a **proven strategy** in achieving glycemic control in T1DM
- **CHO counting in T1DM:**
  - complex task
  - can be challenging
  - related to daily glycemic patterns

